NATURE

No. 4631 SATURDAY, AUGUST 2, 1958 Vol. 182

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INVENTION AND RESEARCH

THE report which Prof. C. F. Carter and Prof. B. R. Williams prepared last year on behalf of the British Association was concerned with the factors which determine the speed of application of science, and it laid stress on the importance of a favourable environment. Competition alone was not regarded as a sufficient condition for technical progress; there must also be provision for fundamental research as well as for industrial research, and adequate educational provision for the training of technologists. Apart, however, from a glance at the patent system, which suggested that the bias of the patent system is towards the disclosure and use of inventions rather than their concealment or suppression, the report was not concerned with the origin of inventions and whether the industrial and social framework to-day was such as to stimulate a free flow of inventive genius and the functioning of creative minds.

The latter could be described as the main theme of a subsequent book by Prof. J. Jewkes, D. Sawyers and R. Stillerman*. It is not so much concerned with the origin of ideas, the functioning of the creative mind, or even with the elements of design and chance in discovery and invention, except in so far as these are affected by the system in which they function. What it really seeks to examine is the place of the individual in industrial society to-day, and whether the forms which the organization of research and development commonly takes have been beneficial or otherwise to inventive work, or whether the ostensible advantages of team-work and large-scale organization have been offset in some tangible or intangible way. To that extent the book overlaps some of the discussion in the symposium on "The Direction of Research Establishments" held at the National Physical Laboratory in September 1956†.

Clearly, the most effective use of scientific and technical man-power demands that we should be clear as to the essential conditions required, just as our industrial efficiency requires that organization should be appropriate to serve those and other needs. It is important that, as this book suggests, the way this or that policy may influence the flow of invention should be considered, and the development of a European Free Trade Area could well give a keener interest in studies in a field of which we know relatively little, though whether ignorance is quite as profound as is here asserted might be questioned. Any necessary connexion between the growth of scientific knowledge and that of technology and invention is not easy to trace, and the need for more actual knowledge about technical and economic change is undeniable. A community, for example, seeking to encourage innovation has little guidance as to how best to proceed, what institutional framework will most effectively stimulate and encourage the men with powers of originality, most rapidly distinguish between the channels open to progress and the blind alleys, and most thoroughly reap the economic harvest from innovation.

Prof. Jewkes and his colleagues do not go very deeply into the problem which confronts every society of how to balance continuity and stability with change and receptivity to new ideas. It is with a comparatively limited aspect of technological change that they are concerned; but they make the fair comment that industrial societies have shown little originality or ingenuity in creating institutions to ensure that all new ideas are caught and nothing lost, and have also not been prolific in devising institutions to encourage invention, though the patent system has been challenged more often than this book would suggest. Again, the decision which every society makes about the proportion of its resources to be devoted to research and invention involves fundamental questions about the ends for which society should strive; and even if it could be shown that invention is to any significant extent a calculable, predictable element which could be embodied into the conscious planning of social and economic activity, that decision is unlikely to be appreciably affected by knowledge of the circumstances in which industrial innovations have arisen in modern times, and of any important changes in their sources between the present and the past century.

Accepting the distinction drawn here between invention and development, with which the book is only to a limited extent concerned—although as in all technology the criteria of achievement in invention is applied ultimately by the user and not, as in science, by the scientist—invention still stands nearer to science than to technology in the development sense. This study of factors which stimulate inventiveness is accordingly of deep interest to all concerned with the conditions which promote creative thinking and with the genesis of ideas. Moreover, if we can answer the questions which the authors put to us, we have still far to go to solve the major problems of development and overcome the difficulties and weaknesses in industry, and in government, to which Prof. Carter and Prof. Williams directed attention. In spite of casual remarks which display the bearing of such societies as the Lunar Society and the Manchester Literary and Philosophical Society on the intermingling of the scientists and technologists of the day, nothing like enough stress is laid upon the importance both to science and to technology of free communication. To provide for such intercourse and mingling and to establish

* The Sources of Invention. By John Jewkes, David Sawers and Richard Stillerman. Pp. xii+428. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 31*s.* 6*d.* net.

† The Direction of Research Establishments: Proceedings of a Symposium held at the National Physical Laboratory on 26th, 27th and 28th September, 1956. Pp. vi+422. (London: H.M. Stationery Office, 1957.) 25*s.* net. See also *Nature*, 178, 964 (1956).

the conditions in which knowledge and criticism are freely exchanged appears to be the vital first step; and when this is secured, the question of the individual or the research team appears to be relatively unimportant.

What deserves more attention than it receives, and could receive, in this inquiry is the improvement of such communications. Scientific and technical literature is indeed extensive, but it is scarcely so easily and cheaply obtained as this book suggests, and some of the conditions which make it less accessible and more expensive are an indirect result of Government policy. So too, while those who are not employed in scientific and technical institutions but are frequently connected with scientific societies and institutions may also derive aid from industrial research associations or government research associations, it should be remembered that it is Government policy which has frustrated the project for a Science Centre in London and also, through the recent change in rating policy, jeopardized the existence of numerous scientific societies.

While it could not be argued that, in general, extensive and detailed records of scientific and technical knowledge are denied to the independent worker of calibre and purpose, it could certainly be shown that Government policy over the past ten years has made the dissemination and discussion of such knowledge more difficult, both for the individual and for the member of a research team. What stands out above all from this study is that the real danger to invention and to creative work arises from the multiplicity of such neglect on the part of the administrator. There is little more evidence to be found for the view that the day of the individual inventor is done or that effective prediction of inventions is possible; the real dangers in team-work arise when attempts are made to organize research in the same way that manufacture is organized and the conditions in which research is most effective are ignored. Even team-work in research is the result of the co-operation of individuals working under conditions which allow full play to their individuality in pursuit of the common goal.

When all allowance is made for the tendency, due to the growing cost of equipment, for research to become a matter for institutions rather than individuals, any dangers inherent in the consequent increased scale of research departments may be offset by the greater opportunities which such institutions can offer for the bringing together of workers in different disciplines. The importance of such cross-fertilization of minds was well brought out in the last annual report from the President of the Carnegie Institution of Washington; but there is a further point which needs to be emphasized, and that is the value of a diversity of institutions. That is important as helping to offset the danger that any one type of institution may become rigid and over-organized; it also meets the problem of helping the individual inventor, whose very originality often makes him difficult to fit into a particular type of organization.

No serious attempt to further inventiveness can fail to take account of those qualities which characterize most inventors, whether they work inside or outside an institution, and which also have something in common with the characteristics of the research worker. To both of them assistance must be given largely on their own terms, and in a way that does not frustrate or destroy originality and initiative; yet it is probably true that this has been—and is—widely neglected. Nevertheless, the influence of that factor alone may well outweigh that of size and organization as such. Whether or not the inventive ability of the community is being increasingly absorbed into organized research institutions, that of itself need not imply that inventors are less free to pursue their own ideas. It is not necessarily a disadvantage that they are less dependent on their own resources, nor is there any evidence that if they are less directly the recipients of the gains to be made from their inventions they are in consequence likely to be less inventive.

Broadly speaking, however, the bias of Prof. Jewkes and his colleagues appears to be against the view that the inventive ability of the community can only be put to the best use if it is increasingly set to work in organized research institutions. In challenging the belief that the day of the individual inventor has gone, they appear to swing too far against the research institution or department. There will always be individuals who will not fit into an organization, and it is important that society should make due provision for such lone individuals or eccentrics. The growing importance of the inventor with a professional training in science and technology is not likely to eliminate this factor, though it may simplify the problem of helping him.

Whether as much importance can be attached to the numerical incidence of inventions within or without the main research institutions or centres is, however, doubtful. If the prediction of invention is difficult, the identification of inventive talent before it has manifested itself is no less impracticable, and unless that is possible the element of chance may well vitiate all the numerical comparisons. The important thing is to see that the inescapable co-ordination and administration, both in industry and in society as a whole, are as dynamic and creative as possible, and to provide the framework within which the individual can express fully his creative and inventive powers.

Apart from this, the picture of large and small industrial laboratories presented as essentially authoritarian and mediocre bodies is open to challenge. Many of them are far from lacking the atmosphere necessary for creative work, and the discussion on creative work at the symposium on the direction of research establishments already referred to indicates that managers are often fully alive to the significance of such factors. Prof. D. J. van Lennep suggested, in fact, that creative research workers are less dependent upon their environment, less rigid and less dogmatic, as well as marked by a characteristic time perspective, perceiving the future as fraught

with possibilities which they themselves could help to realize. Prof. M. I. Stein, from a study at the University of Chicago of factors influencing the creativity of industrial research chemists, suggested that creativity is a result of social environment and processes occurring within the individual; in his view, although we need more knowledge of the way in which environment affects a man's creative powers and of what psychological factors, in a satisfactory environment, stimulate creativity, adequate equipment, a congenial intellectual society and the secure livelihood which the research institution provides are to-day vital requirements for creative activity. Without them the essential tranquillity and concentration on the problem in hand are scarcely possible.

The discussion at the National Physical Laboratory rather than that of Prof. Jewkes and his colleagues seems to point the right way and to identify the problems that require examination. Whether science is playing a greater part in invention and whether inventions are due more to accidental discoveries than to rational planning and research seem to be of secondary importance. Even if the big corporations and research teams are replacing the lone inventor with limited resources, we still need to give much fuller attention to the conditions which foster creative work and invention. It is true that as one aspect it should be considered whether the growth in the scale of invention and development, of government-sponsored research and even changes in university education may tend to diminish invention by increasing resistance to change; quite rightly attention is directed to the value of the uncommitted mind and of the way the grooves of accepted thought may hinder invention. We need, however, to know more about the optimum size of research groups, the way a group functions in developing ideas, and of the effect on such a group and on himself of a really gifted individual.

We have already a good deal of information, of which the Government seems to be unaware, which if acted upon could minimize or eliminate the major dangers to which Jewkes *et al.* direct attention. It is already recognized that research establishments, industrial or academic, can never be too vigilant in fostering original thought; but we could probably make fuller use of the known techniques of selection to place those with creative talents in places where they have the most adequate opportunity of expression. Moreover, the tendency of modern management to become catalytic rather than directive is also in line with what is demanded in the most effective use of creative and inventive talent.

It is in such ways as these that the sources of invention can be kept free and unblocked, and it should be noted that in this whole process the improvement of communications plays a vital part. This is not simply an educational issue, though the development of technological and technical as well as university education could contribute much to a surge of understanding that would increase our ability to encourage and utilize the outflow of creative ideas. It is also a matter of administrative action and improving conditions in a field to which successive Governments have hitherto been indifferent.

That seems to be one of the ways in which immediate action could be taken, and in raising the question of the rating of scientific societies, the opportunity should be used to bring home to the Government the vital contribution which such societies still make to the communication of knowledge and the stimulation of ideas. Attention should be directed, too, to their part in publication, to the handicap which postal charges now place on such undertakings, to the urgent need for an adequate national policy for scientific and technical libraries, and to the practical value of a National Science Centre. Much could be done in ways such as these, while Prof. M. I. Stein and Prof. D. J. van Lennep pursue their studies at the Universities of Chicago and Utrecht. Meanwhile, Prof. Jewkes *et al.* have indicated further questions to which answers could well be sought; but the doubts he expresses as to the teamwork appear to be sufficiently answered by Prof. René Taton, approaching the subject from an entirely different angle in a fascinating essay, "Design and Chance in Discovery and Invention", published in *Impact* (Paris: Unesco) some two years ago. The dangers lie, in fact, not so much in the institution as in the way it is used, and the further knowledge continually being gathered as to how to use our institutions could well offset any increasing difficulty for the independent individual to exercise his inventive faculty, which Prof. J. D. Bernal believes is inherent in the nature of modern industry.

FROM DIVINE TO CONTINUOUS CREATION

Theories of the Universe from Babylonian Myth to Modern Science

Edited by Milton K. Munitz. (The Library of Scientific Thought.) Pp. x+437. (Glencoe, Ill.: The Free Press; Indian Hills, Colorado: The Falcon's Wing Press; London: George Allen and Unwin, Ltd., 1957.) 48*s.* net.

WITH the multiplication of courses on the history of science there has come from publishers an increasing and welcome flow of source-books and translations of all kinds, particularly of trans-Atlantic origin. For example, the McGraw-Hill series of 'readings' from classic originals in mathematics, physics, chemistry and so on has been widely known and used. Now Mr. Milton K. Munitz, of New York University, has had the excellent notion of producing a similar set of 'readings' to illustrate the evolution of cosmological theories. In his volume the extracts are somewhat longer and more complete than in some of its predecessors—a point in its favour; and he has not chosen from among contemporary sources only, but has reprinted passages from recent historians and expositors. This seems a less satisfactory innovation. The works of writers like Cornford, Dreyer or Francis

Johnson can rarely be so very inaccessible to students or even to the general reader; and the inclusion of the interpretation of some historical phase by a single scholar in a collection of this kind, however eminently enlightening his views may be, is likely to set a stamp of infallibility upon them. In Mr. Munitz's book the only pieces on the period between Ptolemy and Copernicus are twenty-four pages from Dreyer's well-known history of planetary theories (available for some time in a cheap reprint) and an extract of three pages from Nicholas of Cusa's "De docta ignorantia". Dreyer was a learned and careful writer; but he wrote of almost everything medieval in terms of contempt, and the section here reprinted concludes with Dante. It would have been more just to contrast the primitive conceptions of some medieval Christians with the rational and open discussions of such a philosopher as Oresme in the fourteenth century. Medieval philosophers had more serious problems than the calculation of the number of angels who could dance on a needle-point; medieval cosmologists had more serious problems than determining the site of heaven and hell—though it is unclear why this should not be a matter of interest to a professed Christian.

The choice of authors in an anthology like this is virtually dictated, and proceeds (as the sub-title indicates) from Jacobsen's account of Babylonian creation-myths through the Ionians, the famous later Greeks, Copernicus, Galileo, Newton, Herschel and others to a relatively much more ample extraction from the modern cosmologists—Willem de Sitter to Fred Hoyle. To these last more than a third of the whole book is devoted. Within the range of authors an anthologist has a freer choice: Mr. Munitz has usually, though not invariably, hit upon passages that contain the kernel of a conception. His Lucretius is fascinating; his Ptolemy demonstrates the obvious fact that Ptolemy was great as a technical astronomer, not as a creative thinker; his Galileo, unfortunately, is rather dull—a statement of the Copernican system, certainly, but not an introduction to the intellectual exhilaration of Galileo's writings, nor indicative of his great cosmological theme, that the universe is a system of physically similar bodies, subject to the same physical laws. It was a pity to omit Descartes, for his idea of the universe changing in time. Again, the passages taken from Newton are well worthy of study, including the four letters to Bentley; yet one misses inevitably the foundation of exact science that underlay Newton's wider (and more vulnerable) ideas, and that constitutes the solidity of the "Principia". It is indeed difficult to see how cosmological theories can be presented in manageable form along with their necessary substratum in the observable facts of astronomy and astrophysics; but it is by its relation to the available substratum of science that any theory of the universe must be judged as a contribution to the intellectual development of its time.

One cannot say that there is much here that is not accessible fairly readily and in English; nevertheless, it is valuable to have typical passages reprinted, and the close juxtaposition of conflicting arguments is highly stimulating. The collection will be a convenient introduction to one area of controlled speculation which has always furnished a major theme in the growth of science. As such, it is worthy to stand by others of the same kind as a volume to which both teachers and students will often turn with profit.

A. R. Hall

NICOLAUS STENO

Nicolaus Steno and His Indice

Edited by Gustav Scherz. (*Acta Historica Scientiarum Naturalium et Medicinalium*, Vol. 15.) Pp. 314. (Copenhagen: Ejnar Munksgaard, 1958.) 32 Danish Kr.

THE life of Nicolaus Steno (1638–86) falls, broadly speaking, into two periods, the scientific (to 1674) and the priestly. A notable figure among the many great scientists of that formative period, the seventeenth century, Steno made important contributions to human and comparative anatomy, embryology, geology and palæontology; and his studies of crystals of quartz have earned him the title of 'Father of Crystallography'.

In this small volume, a concise biography by G. Scherz is followed by essays by six other contributors: "Nicolaus Steno's Contribution to Zoology", by Ragnar Spärck; "Nicolas Sténon Paléontologiste", by Rémacle Rome; "Nicolaus Steno and Scientific Geology", by Axel Garboe; "Niels Stensen und die Kristallographie", by Heinrich Tertsch; "Niels Stensen und der Cartesianismus", by Adolf Faller; and "The Influence of Nicolaus Steno on the Development of Geological Science in Britain", by V. A. Eyles.

The essays by Dr. Garboe and Fr. Rome trace the development of Steno's notions of geological strata and his conviction that fossils are indeed the remains of living animals. These ideas, and similar ideas developed independently by Robert Hooke, led to a long-drawn-out argument over the origin of fossils; Dr. Eyles reviews the beginnings of this controversy, with particular reference to the independence of Hooke's and Steno's work and to the continued appreciation and citation of Steno's arguments by British scientists when they were forgotten over much of Europe.

Of Steno's pioneer work in crystallography, his discovery of the constancy of crystal angles throughout all variations of habit is well known, but it is less generally realized that his studies of ghost quartz and of zoned inclusions led him to conclude that crystals grow, and grow by apposition of new layers on the several faces, a very different mode of growth from that of living beings; he noted that the rate of accretion varies on faces belonging, in modern terms, to different forms, and endeavoured to account for the striations on the prism faces of quartz, and the tendency to a tapered prismatic habit. Dr. Tertsch gives an excellent review of Steno's work on quartz, pyrite and hæmatite crystals, and points out that Steno's measurements were not wholly interfacial angles as is commonly assumed; some at least were interzonal (inter-edge) measurements.

Steno's scientific work was largely based on two collections of natural objects, his own and that of the Grand Duke, which are known to have been housed in Florence; it is probable that some at least of this material still survives, though none can now be traced with certainty. But copies of a catalogue exist that was almost certainly originally written or dictated by Steno; the descriptions of crystals, minerals and fossils in this catalogue are of great interest, and it forms one of the most useful features of this book. Dr. Schertz has collated and reprinted the Italian text with an English translation and with extensive and valuable notes.

M. H. Hey

PHARMACOPŒIAS AND FORMULARIES

British Pharmacopœia 1958

Pp. xxvi+1012. (London: The Pharmaceutical Press, 1958. Published for the General Medical Council.) 63*s*. net.

British National Formulary, 1957

Pp. 226. (London: British Medical Association; and the Pharmaceutical Society of Great Britain, 1957.) Standard edition 6*s*. 6*d*.; Interleaved edition 10*s*.

British National Formulary, 1957

Alternative edition based on a Pharmacological Classification. Pp. 245. (London: British Medical Association; and the Pharmaceutical Society of Great Britain, 1957.) 7*s*. 6*d*.; Interleaved edition, 10*s*. 6*d*.

The Extra Pharmacopœia

Vol. 1 (Martindale). Twenty-fourth edition. Pp. xxx+1695. (London: The Pharmaceutical Press, 1958.) 65*s*.

IT is a hundred years since the General Medical Council became responsible for publishing "The British Pharmacopœia". The present issue is the ninth since that date and it becomes official from September 1 when the standards laid down for the medicaments included will be legally enforceable and supersede those of the eighth edition of 1953 and its addendum of 1956. The work of selecting drugs for inclusion in "The Pharmacopœia" and of setting standards for them is delegated to the British Pharmacopœial Commission assisted by expert committees, and it is the present intention that a new edition should be produced every five years. Each succeeding issue marks the trend of medical practice from the empiricism of the nineteenth century (dependent mainly on natural products for drugs) towards the physician's ideal of using pure substances of known and precise pharmacological action. Belladonna root, mercury ointment and quassia are well known substances which at last, with 135 other items, have fallen from official favour to make way for 160 new monographs, including such names as acetazolamide, prednisolone, and tetracycline hydrochloride. It is interesting to note that phenylbutazone, which was considered sufficiently well established as a therapeutic agent to be included in the 1956 addendum, is deleted in this edition, presumably because of adverse clinical reports about it in the past two years. For the first time radioactive materials, the sodium salts of radioiodine-131 and of radiophosphorus-32 appear as monographs.

The break with tradition, begun in 1953, of using English titles for monographs instead of Latin headings has continued, and in this issue many of the English titles have been simplified. However, many modern medicaments are produced under registered trade marks and patents held by individual firms which give their products names different from those selected by the Commission. To aid those in medical and pharmaceutical practice to identify brands of official medicaments, the Commission has authorized the publication of a pamphlet, listing approved names and the other names by which a medicament may be known, for use in conjunction with the new pharmacopœia.

Standards for drugs and medicaments naturally become more exacting and complex with each succeeding issue of "The British Pharmacopœia" and must of necessity refer to equally important standards of other official bodies. Close collaboration between such bodies is to be expected and it is disappointing to find that determinations of viscosity are based on apparatus described in British Standard 188 of 1937 instead of the current issue of 1957. Apart from this lapse I have great admiration for the general quality of the latest publication. The Commission and especially the editor are unreservedly to be congratulated on a fine production.

Similar congratulations should be extended to the Joint Formulary Committee for producing "The British National Formulary, 1957". This is the fourth edition of what has hitherto been known as the "National Formulary", the change in title being introduced to avoid confusion with the United States book of standards of the same name. Whereas "The British Pharmacopœia" is primarily a collection of specifications for drugs and is to be found on the manufacturer's and analyst's bookshelves rather than in the consulting room, "The British National Formulary" is the constant companion of every physician and pharmacist in general practice. The standard edition follows the traditional pattern for this pocket-book, containing notes for prescribers, useful information on the treatment of poisoning and identification of medical gas cylinders, as well as the formulary of medicaments set out in pharmaceutical types (mixtures, injections, eye-lotions, tablets, etc.). This classification, however, while of great use to the pharmacist, can be inconvenient for the prescriber who thinks of his medicaments in terms of the action that they will produce. To meet this situation an alternative edition has been issued based on a pharmacological classification, with added comments on the use and reactions of the drugs listed in the standard edition.

However useful the pharmacological edition of "The British National Formulary" may be, it must of necessity remain a pocket-book, limiting the scope and the amount of information which can be incorporated. The need for a comprehensive reference book giving medical and pharmaceutical information on the majority of medicaments in present use is obvious. This need has been filled for many years by "Martindale's Extra Pharmacopœia", which first appeared in 1883 as one volume. Such has been the progress of medical knowledge that by the fifteenth edition in 1911 the information to be incorporated required the work to be split into two parts, Vol. 1 being devoted to the medical and pharmaceutical properties of medicaments and Vol. 2 to descriptions of ancillary subjects such as analytical standards, hæmatology, sterilization and disinfection, etc. The twenty-fourth edition of Vol. 1 is completely rewritten and is probably the most useful work of reference available in this field to-day. The keys to the book are the general index containing nearly 20,000 entries and the therapeutic index indicating possible treatment for nearly 800 medical conditions. I noted with pleasure that although "Martindale" was published only one month after "The British Pharmacopœia 1958", the co-operation between those responsible for the two books has been such that the main changes introduced by the official standard are indicated in a special section (and, more important, in the index) of the "Extra Pharmacopœia". In addition, twenty-four other pharmacopœias and

related publications from all over the world have been examined and relevant material noted. Careful editing has been necessary in the selection of abstracts referring to specific substances and this has been admirably executed. This book is an essential part of the libraries of all who are connected or interested in any way whatsoever with medicine and pharmacy.

David Train

SOCIAL CHANGE IN SIMPLER SOCIETIES

Yulengor

Nomads of Arnhem Land. By Wilbur S. Chaseling. Pp. xxvi+173+13 plates. (London: The Epworth Press, 1957.) 21*s*. net.

Easter Island

A Stone-Age Civilization of the Pacific. By Dr. Alfred Metraux. (Translated from the French by Michael Bullock.) Pp. 249+16 plates. (London: Andre Deutsch, Ltd., 1957.) 21*s*. net.

Work and Life on Raroia

An Acculturation Study from the Tuamotu Group, French Oceania. By Dr. Bengt Danielsson. Pp. 244+7 plates. (London: George Allen and Unwin, Ltd., 1956.) 25*s*. net.

Social Change in the South Pacific

Rarotonga and Aitutaki. By Prof. Ernest Beaglehole. Pp. x+268. (London: George Allen and Unwin, Ltd., 1957.) 28*s*. net.

THE theoretical and the practical importance of the social changes that have been taking place in the technologically undeveloped communities have led to the production of many books on the subject in recent years. These four works deal with the results of Westernization on indigenous peoples in Polynesia and in Northern Australia. Three of them, concerned with agricultural Polynesian communities, are by professional anthropologists; one, on the Arnhem Land nomads, is by a layman.

"Yulengor"—the name is the East Arnhem Land equivalent for aboriginal nomads—has been written by a missionary of long experience in the region. He landed there in 1934, and the results of his close sympathetic observation over a number of years make extremely interesting reading. He describes the domestic life, the hunting and collecting economy of these still primitive people, their initiation, burial and other rituals, their magic, their creation myths. The treatment is not very systematic, but a useful introduction by Prof. A. P. Elkin supplies the framework of the aboriginal social structure. The picture presented is one of extreme simplicity of life. Mr. W. S. Chaseling states that "the daily life of the people has not changed in a thousand decades and still involves hunting with stone and wooden spears and stone axes for everything the nomad eats". But he also says that metal has been filtering into the country for two centuries, and this has made hunting for sea-animals—such as turtle and dugong—easier. Again, nearly all the people in his photographs wear a modicum of clothing. This and other evidence indicates what anthropologists are by now well aware of, that even here the primitive Australian has undergone considerable change in his mode of life through foreign contact.

Dr. A. Metraux's book is a craftsman's job. Easter Island has provided one of the popular mysteries of the world and, as Dr. Metraux says, many audacious solutions to its problems have been provided. He himself gives an admirably clear, sober outline of the whole situation. He describes the traditional culture of the islanders and the radical, often tragic, changes that the community has undergone since Europeans first called there. He indicates the problems of origin and function connected with the cultural remnants now left to us. He does not shirk the difficulties of the problems. In particular, his own interpretation of the mnemonic and symbolic function of the wooden tablets "carved with script" is given as definitely provisional. He is equally critical and firm about the various theories put forward by others about the origins of Easter Island civilization in external sources. His own conclusion, that Easter Island sculpture, including the great statues, represents a specialization of Polynesian culture—probably from a Marquesan source—favoured by particularly local conditions, is one which has strong anthropological support. The book is a condensation and revision of an earlier scientific monograph, and while primarily for the non-specialized reader, may be taken as an authoritative statement.

In "Work and Life on Raroia", Dr. B. Danielsson continues in scientific vein his study of the Tuamotu Island community among whom he landed, in company with his companions of the Kon-Tiki raft, in 1947. This study of the social and economic condition of the community of rather more than a hundred persons is very detailed and one of the most useful accounts of a Polynesian island economy which we possess. The author studied the modes of production, both for subsistence and for cash exchange, the land tenure, and the income and expenditure patterns of the people. He prefaces his analysis by a detailed examination of the demographic condition and of the history of their contacts with other cultures. The changes in the society have been considerable. Apart from concentration of residence in a single village, there has been a decrease in the size of kin groups, a high degree of individualization of work as a result of the introduction of a competitive money economy, and a breakdown of the former system of hierarchical authority. Surprisingly for Polynesia, a man who wants to build a house must pay the workers in money, at wages almost as high as in Tahiti. For such a small population, the analysis of the figures is perhaps over-elaborate and the data on social structure too thin. But as the author points out, so far very few anthropological studies have been made of modern Polynesian communities showing the ways in which individuals and groups have responded to the varying local conditions of contact. This work is a very useful contribution to the study of acculturation process in the Pacific.

The study of Rarotonga and Aitutaki by Prof. E. Beaglehole is of a much broader character—indeed, its title goes much further than its content. The author has had a great deal of experience in studying Polynesian communities already, and the results of this emerge in his penetrating analysis and comprehensive generalizations. He has supplemented the limited amount of field research he was able to manage with a careful examination of the historical records. Using both an anthropological and a psychological frame of reference, he has given a valuable study of the history of social change in these two communities. He has also suggested a typology for

such change and singled out clearly the various major factors in the process. Much of his analysis is concerned with the part played by missionary and Government official in the island communities, but a very substantial part of the book covers their demography, their economy and their social structure. A concluding section relates his findings to the administrative problems of development and welfare that now urgently concern the New Zealand Government, which has the responsibility for care of these islands.

All these works are worth reading for their sincerity and insight into an important aspect of modern social process.

RAYMOND FIRTH

A COMPREHENSIVE HANDBOOK ON THE CARE OF LABORATORY ANIMALS

The UFAW Handbook on the Care and Management of Laboratory Animals

Edited by Alastair N. Worden and W. Lane-Petter. Second edition, greatly enlarged. Pp. xix+951. (London: Universities Federation for Animal Welfare, 1957.) 70*s*. net.

EVERY scientist who uses laboratory animals should realize the importance of good stock husbandry. Technical, as well as humane, considerations demand that experimental animals be kept under the best possible conditions, for environmental irregularities can confuse experimental results. This publication contains a wealth of knowledge on the management of nearly all the species of animals used in laboratories, and can be used as a guide to their respective needs by any worker who is seeking detailed information. This second edition is far more extensive than the first, and the additional matter included comprises not only knowledge acquired during the past ten years, but also details of additional species. More than eighty recognized authorities have contributed, for each chapter has been prepared by a worker who is an expert on the subject with which it deals.

The first part of the book is devoted to general considerations which apply to nearly all species. Subjects covered include the legal protection of laboratory animals, the designing and equipping of animal houses, the principles of hygiene, breeding methods, feeding, handling, anæsthesia and euthanasia.

The second part is devoted to comprehensive accounts of the many different species which are used for experimental work, and more than fifty species are dealt with individually. This part is subdivided on the basis of zoological classification. The first group deals with the rodents and lagomorphs, including the guinea pig, the rabbit, and various species of voles, rats, mice and hamsters. The shrews and hedgehogs, which are insectivores, are next described. The carnivores, such as the cat, dog, fox, ferret, mink and marten, follow. The ungulates, including the sheep, goat, horse and pig, form another group, and in small groups on their own are the primates and marsupials. Among the bird species included are the fowl, pigeon and canary. Other groups covered are the reptiles, amphibia and fish, and a miscellaneous group of invertebrates. Finally, some notes are given on more than twenty other species not dealt with in detail.

The information on each species is clearly set out, and most chapters contain information on accommodation, feeding, breeding, handling and disease control. A comprehensive list of references is given at the end of each chapter. The amount of space devoted to each species has been carefully controlled, and a well-balanced book has resulted. There is both a subject and an author index. The book is illustrated by clear photographs and diagrams dealing particularly with various types of cages and equipment.

This book will undoubtedly be widely read by scientific workers who use experimental animals, and could, with advantage, be provided as a standard reference book in all institutes where laboratory animals are kept. The contributors are to be congratulated on the way in which they have recorded the knowledge they have acquired by experience, and a debt of gratitude is due to the Universities Federation of Animal Welfare for producing this book, which will do so much to make this knowledge readily available to all who use or tend laboratory animals.

J. O. L. KING

MAN–ANIMAL RELATIONSHIPS

Tuberculosis in Animals and Man

A Study in Comparative Pathology. By Prof. John Francis. Pp. xvi+357+40 plates. (London: Cassell and Co., Ltd., 1958.) 105*s*. net.

PROF. FRANCIS has collected within the covers of one volume a vast amount of information on tuberculosis in both animals and man, gleaned from sources in all parts of the world. At this time when the elimination of tuberculosis from cattle in Great Britain is progressing rapidly and the time is within sight when the disease will disappear altogether from our herds, it is helpful to have before one this large volume of information of the disease in other species, including man, since these reservoirs of infection could well prove a menace to the maintenance of disease-free herds.

The earlier chapters of the book, which deal with the pathogenesis and pathology of bovine tuberculosis and the control of this disease in cattle, are by no means outdated by the fact that the disease in cattle may soon disappear from Great Britain; indeed, if it is to be prevented from re-establishing itself among our herds a sound knowledge of its pathology and epidemiology is essential.

Prof. Francis deals with the disease in monkeys, guinea pigs, rabbits, voles, elephants, buffaloes, all farm animals (including poultry, dogs and cats), camels, mink and silver foxes, rats and mice, wild animals, ferrets, hamsters, birds and finally cold-blooded animals. At the end of each section of the book the author presents a complete list of references so that the reader can refer to the origin of information dealing with the disease in each separate species of animals. As most of the information contained in the book is factual and supported by clear references, the work invites little or no challenge of opinion. Even so, where the author does draw deductions from the information which he has gathered together, or offer opinions on the significance of the information available, he does so with commendable restraint and the reader will greatly appreciate the complete and objective impartiality with which the work has been compiled.

Illustrations, though not exceptionally profuse, are clear and truly illustrate what they are intended to portray. The author is to be congratulated on producing a work of the utmost interest and value to all who are interested not only in tuberculosis but also in comparative pathology in its widest sense.

This volume will be widely read and highly appreciated in both medical and veterinary circles throughout the world. HAROLD BURROW

CRYSTAL STRUCTURES

Structure Reports

Edited by A. J. C. Wilson. Vol. 8: 1940–1941. Pp. viii+384. 80 Dutch florins. Vol. 9: 1942–1944. Pp. viii+448. 65 Dutch florins. Vol. 15: 1951. Pp. vii+588. 110 Dutch florins. (Utrecht: N.V. A. Oosthoek's Uitgevers Mij, 1956 and 1957.)

THE possibility of considering more than one volume of "Structure Reports"—intended as an annual reference work—in a single review is proof of the welcome fact that the editors are fulfilling their promise not only to keep the series up to date, but also simultaneously to bridge the gap of the war years. This gap is now happily closed with the appearance of Vol. 8, which contains such classical work as the structure of melamine (in which mathematical refinement techniques now in general use were first introduced), the observation that diffuse scattering is a widespread and informative phenomenon, and the X-ray studies of the phthalocyanines.

In all three volumes, as usual, the coverage is excellent, the format acceptable, and the information admirably distilled. The series now forms an excellent starting-point for the systematic analysis of the fruits of some forty years of international endeavour involving the determination of many hundreds of crystal structures—organic, inorganic and metallic—by a variety of diffraction techniques, supplemented by such structural information as may be obtained from other disciplines like spectroscopy.

Published work has not been abstracted blindly. On the contrary, detailed assessments of each structure have been made, and critical comments are inserted by the editors where they have felt it necessary to do so. This critical analysis of published structures is a particularly valuable feature of the series. The vast amount of calculation necessary to extract the maximum information even from experimental data of only moderate quality makes it virtually certain that many published structures could be made to yield more accurate results than those with which one had to be satisfied before the advent of digital computers. On the other hand, high-speed computation allied with a failure to recognize the limitations of the data themselves merely permits us to reach a wrong answer faster than ever before.

Crystallographers generally are alive both to the potentialities and to the dangers of the present stage of development of the subject, and the standing of the editors in their own field is an adequate guarantee that non-crystallographers using these volumes will have the benefit of a sound assessment of the expanding stream of crystal structure analyses which look so impressive in the learned journals. Pondering the rapid increase in size and complexity of solvable structures, one is reminded of the optimistic advertisement—"the impossible we do at once; miracles take a little longer"; and miracles they truly are, for modern techniques are now carrying us, within the life-time of many of the original pioneers of X-ray crystallography, from the sort of crystals the structures of which a physicist can draw from memory to the sort of molecules which lie near the root of life itself. These volumes provide a worthy record of this continuing advance. It is a pity that their price makes them a luxury when their importance renders them a necessity. H. J. GRENVILLE-WELLS

METABOLISM OF THE NERVOUS SYSTEM

Metabolism of the Nervous System

Edited by Derek Richter. Pp. xiv+600. (London and New York: Pergamon Press, 1957.) 100*s*.

THE central nervous system provides more fascinating problems than any other part of the body and scientists all over the world are studying it from many points of view and travelling to meetings and symposia and congresses to discuss their results. These discussions often appear in book form and the present work is one of the most valuable of these books. It is based on the Second International Neurochemical Symposium, which was held at Aarhus, Denmark, in July 1956. It is divided into thirteen sections each dealing with a different aspect of the metabolism of the nervous system. Each section opens with a general review, which is followed by shorter and more specialized papers. There is so much that is valuable that it is impossible to mention more than a few examples of interesting contributions. There are some fine reproductions of pictures obtained with the electron microscope, there is a discussion by A. Engström of the use of X-rays to analyse structure, and a discussion of the blood-brain barrier, and various other barriers. R. D. Keynes discusses electrolytes, F. Brink discusses nerve metabolism, S. S. Kety discusses the metabolism of the brain as a whole and J. H. Quastel discusses the metabolism of tissue preparations of brain. O. H. Lowry describes experiments in which he dissects out single cells, weighs them and measures enzymes in them. As the total weight is often less than 0·01 μgm. this requires a rather special balance, but he hopes to extend his technique to single mitochondria.

R. V. Coxon, R. J. Rossiter, L. Einarson and H. Waelsch discuss the metabolism of carbohydrates, fats, nucleic acids and proteins respectively. W. Feldberg discusses acetylcholine, U.S. v. Euler and M. Vogt discuss noradrenaline, S. Udenfriend discusses 5-hydroxytryptamine and J. Crossland discusses all the other active substances which might possibly act as chemical transmitters.

It will be seen that this book covers a wide field, but only a small proportion of the papers have been mentioned; there are well over fifty altogether. It is a valuable guide to the results obtained by many different methods written by the leading authorities. Many of the papers are followed by short discussions, which help those who were not there to form a judgment of their importance. The book is beautifully produced but expensive. Libraries will have to buy it; individuals working in this field will buy it if they can afford it. J. H. GADDUM

AN INTERNATIONAL MILK TEETH RADIATION CENSUS

By Dr. HERMAN M. KALCKAR*

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WITHOUT expressing here any opinion concerning atomic weapons test programmes, I wish to suggest a scientific study which would at the same time have educational values in its practical demonstration of the peaceful applications of atomic research. The suggestion arises from the belief that any family, regardless of whether or not its country has ambitions in the development of atomic weapons, would be sympathetic to and support an international study involving atomic radiation and ultimately concerned with the health of its own children.

It is generally recognized that young children take up radioactive strontium and cæsium more intensely than adolescents and adults. It is most likely that they also have higher biological radiosensitivity, regardless of whether the dosage results from radioactive strontium, cæsium, iodine, or X-rays. Hence radiation hazards, both those stemming from the peaceful use of atomic power and those having to do with the military use of nuclear energy, must be recognized as being greater during early childhood. Moreover, modern biology has demonstrated the incidence in various human races of certain aberrations, such as defects in reductive metabolism. These considerations, together with the great need for precise knowledge of the biological factors involved, should be stressed to the general public and to all those whose informed participation would be essential to the success of the project to be described.

The official public health agencies of every nation, and especially of the British Commonwealth, China, India, the United States and the U.S.S.R., should organize a large-scale collection of milk teeth (with dates of appearance and shedding, and the child's age in each instance) and conduct measurements of radioactivity on this material. Thousands of countings, performed on a decentralized basis in individual communities and collected on a national basis, would be essential, both to ensure the validity of the results and to assure a widespread sense of active participation on the part of the people of many nations.

Such an International Milk Teeth Radiation Census would contribute important information concerning the amount and kind of radiation received by the most sensitive section of any population, namely, the children. At present, important although rather erratic data exist, based on autopsy of bone samples derived mainly from adults. If a study of a large-scale collection of deciduous teeth were to be initiated in order to confirm and extend these data, it would require an extensive technical organization, adequate equipment, and trained personnel.

Early work by Hevesy, Holst and Krogh[1], Armstrong[2] and Pedersen and Schmidt-Nielsen[3] made it clear that dental enamel takes up phosphorus-32 rapidly during its formation but does not significantly renew itself; dentine renews itself to a detectable degree but much more slowly than bone. Dr. Wallace Armstrong, University of Minnesota, and Dr. S. Kreshover, National Institute of Dental Research, directed my attention to the fact that measurements of radiation from deciduous incisor teeth would reflect the situation as it existed about seven years previously, namely, at birth or shortly before, when the calcified structure of the deciduous teeth is deposited. At present it would seem necessary to pool several deciduous teeth in order to acquire sufficient material.

The proposed milk teeth census is, of course, a long-range programme. If a continued general trend toward a rise in radioactivity in children's teeth were ascertained, it might well have important bearings on national and international policy. The results should be conveyed to the public without interpretations which might give rise to either complacency or fear, but rather in a spirit that would encourage sober, continued, active concern. It should be emphasized that the data would portray the situation as it existed about seven years previous to the study. In spite of this, the fact that these data would give a general estimate of the exposure of newborn children to radioactivity should be stressed.

Measures to keep the radioactivity of teeth and bone structure at low values, especially in young children, should—in accordance with the results of the study—be initiated with full public explanation, emphasizing the limitations of such measures. In connexion with the diet, the increasing use of soybean milk, especially in the Orient, would make it of interest to compare the radioactivity in milk teeth of children reared on soybean milk with that of children drinking cow's milk. The former might be less radioactive because the added calcium stems from rock which represents ancient deposits that have not been in contact with radioactive fall-out. However, the calcium present in the soybean itself may actually exceed that of dairy milk with respect to concentration of strontium-90. An appreciable group of children inhabiting the Pacific islands and Japan derive their calcium intake from fish-bones which might be relatively high in strontium-90, although the dilution factors of the ocean may tend to produce lower values.

It would be most effective if the International Milk Teeth Radiation Census could be carried out simultaneously, or nearly so, throughout the world. The United Nations might be the best agency to handle such a project. It would be particularly impressive if the Western world—which has contributed so greatly to the development of ingenious tools for the peaceful use of atomic energy—took the initiative by offering to make its equipment and technical advice available to any country interested in participation in this project. India, for example, would be uniquely equipped to give impetus to the study in the Orient, both as a direct participant and as a means for contact with China and other countries of the Far East which would have much to contribute.

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In another continent, the Scandinavian countries, and notably Denmark, might be in a position to play a comparable part. Such a concrete demonstration of respect and reverence for life, regardless of creed, colour, or political system, might well contribute to a growing feeling of confidence among nations, and a special confidence in those nations which might elect to give initiative to or participate in a world-wide study of this kind.

It is a pleasure to express my gratitude to Dr. Warren Weaver, vice-president of the Rockefeller Foundation, for his kind interest and encouragement and for his valuable advice during the formulation of this article.

[1] Hevesy, G., Holst, J. J., and Krogh, A., *Kgl. Dan. Vidensk. Selsk. Biol. Medd.*, **13**, 1 (1937).
[2] Armstrong, W. D., "Ann. Review of Biochem.", **21**, 415 (1942).
[3] Pedersen, P. O., and Schmidt-Nielsen, B., *Schweiz Monatsschrift Zahnheilk*, **51**, 647 (1941); *Acta Odontol Scand.*, **4**, 1 (1942).

THE INTERNATIONAL SCIENCE HALL AT THE BRUSSELS EXHIBITION

THE exhibition in the International Science Hall at the Brussels Universal and International Exhibition is designed to show the aims, methods, and results of pure scientific research in the fundamental sciences, with a special emphasis on developments since the last World Exhibition was held in New York in 1939. The exhibits are restricted to four main topics of research—the atom, the crystal, the molecule and the living cell—and are arranged in the main body of the hall in four overlapping sections, one for each of these subjects. The growth of science from the earliest times to the present day is illustrated in the entrance hall.

The scope of the exhibition is perhaps best indicated briefly by a list of the headings under which the exhibits are described in the catalogue. In "The Atom" section these are: atoms and nuclei, isotopes, radioactivity, neutrons and fission, nuclear reactors, accelerating machines, elementary particles, cosmic rays, cloud and bubble chambers and nuclear plates, solar energy and thermonuclear reactions. In "The Crystal" section they are: the crystal lattice and lattice defects, the determination of crystal structures, crystal growth, dislocations and diffusion, phase changes, mechanical properties, electrical and magnetic properties, optical properties and crystal surfaces. In "The Molecule" section the main headings are: chemical bonds, molecular energy states, structural properties, techniques of separation (including thermodiffusion and chromatography), catalysis and kinetics, surface phenomena, colloids, radiochemistry, general chemistry and macromolecules. Finally, in "The Living Cell" section, the exhibits are concerned with the chemical constituents of cells, genetics, radiobiology, viruses, bacteriophage and bacteria, protozoa and fungi, photosynthesis and vegetable cells, animal cells and embryology.

The idea of staging an international exhibition of pure science as part of the Brussels Exhibition was due entirely to the Belgians, who have also provided the hall, the essential organization and a large number of the exhibits. Fourteen other countries, Austria, Czechoslovakia, the Federal German Republic, France, Holland, Israel, Italy, Portugal, Spain, Switzerland, the United Kingdom, the U.S.A., the U.S.S.R. and Yugoslavia, have also contributed to it. The overall plans were made by a committee of scientists from all the participating countries under the chairmanship of Prof. Robert van Cauwenberghe, and the exhibits were selected and co-ordinated by four sub-committees with the Belgian scientists, Profs. M. de Hemptinne, W. Dekeyser, G. Smets and P. Bordet, as chairmen respectively for the Atom, Crystal, Molecule and Living Cell sections. The individual exhibits, of which there are about five hundred, have been devised by leading scientists in the contributing countries, generally with the assistance of professional designers.

One of the principal objects of the organizers is to show that pure scientific research is a truly international activity. A great deal has been done, therefore, to avoid attracting attention to the differing nationalities of the contributors and to emphasize the aims and methods they have in common. The exhibits are arranged strictly according to their scientific content without regard for their country of origin; they are more or less uniform in design and the names and countries of the scientists responsible for them are displayed for the most part in an unobtrusive manner. Naturally enough, the exhibits do not all conform exactly to the recommended standard pattern, but there is certainly enough general uniformity of design for the organizers' main aim to be realized, and the few exhibits that are markedly different add a necessary touch of variety to the whole.

It is hoped that all sections of the public will visit and profit by this exhibition, and exhibits have therefore been provided both for laymen and for specialists. In addition, the Belgians have made a special introductory film in which most of the concepts necessary for an understanding of the exhibits are introduced in simple terms for the benefit of visiting non-scientists. This film is shown at regular intervals during the day in a special cinema inside the hall, every seat of which is equipped with ear-phones on which the film commentary can be heard in any one of the five languages, French, Flemish, English, German and Spanish. There are two smaller cinemas in which programmes of the best scientific films made by all the contributing countries are shown.

The exhibits in the hall are of three main types. Those of the first kind are intended to supplement the film in introducing the fundamental ideas and principal experimental techniques of modern research to visitors with little or no scientific training. These exhibits include, for example, atomic models, explanatory models of instruments such as the cyclotron, a demonstration of diffraction phenomena and their use in crystal structure analysis, an explanation of chemical bonding and an account of the Mendelian laws of heredity vividly illustrated in a collection of birds and animals. The exhibits of the second type are historical and show by means of original documents and models and replicas of famous apparatus the development of important experimental tech-

niques and the performance and significance of crucial experiments. Among them may be noted the account of Becquerel's discovery of radioactivity in uranium, a model of the laboratory in Cambridge where Cockcroft and Walton first split the atom without the use of natural radioactivity, and a replica of the remarkably simple apparatus with which Hahn and Strassmann first recognized nuclear fission.

The remaining exhibits, those of the third type, which far outnumber the rest, are concerned with the methods and results of the latest research. They include a great deal of working apparatus—in the Atom section, for example, there are two working nuclear reactors—and many of them are concerned with quite advanced ideas. The general level of difficulty in fact approaches that of the exhibits at a Royal Society conversazione. It is scarcely fair to single out any of these exhibits for special attention, but some account of the Russian exhibits may interest the many people who are unlikely ever to visit the U.S.S.R., and it will also serve to indicate the standard attained by the exhibits in general. They are characterized by large frameworks standing on illuminated bases of metal and glass and carrying diagrams and models in fluorescent paint and neon lights which illustrate the subject of the exhibit. These centre-pieces are designed to attract attention to the exhibits, the serious contents of which generally consist of the latest apparatus, usually in working order and operated by a resident staff of scientists and technicians, and accounts of the results obtained by its use. Thus in the Crystal section the Russian exhibit on crystal structure determination by means of X-ray and electron diffraction consists of an array of crystal structure models mounted on a characteristic centre-piece, alongside an elegant apparatus for electron diffraction studies of single crystals from the Crystallographic Institute of the Academy of Sciences in Moscow. In the Molecule section the exhibit on chain reactions by Prof. N. N. Semenov, who shared with Sir Cyril Hinshelwood the 1956 Nobel Prize for Chemistry, has for its central feature an elaborate panel in which the course of various reactions is illustrated by means of automatically controlled lights. This is surrounded by apparatus used in the study of such reactions, including a mass-spectrograph for the study of free radicals, a high-speed camera for the study of explosions and an apparatus for the study of reactions under high pressures.

The British contribution of more than fifty exhibits in all parts of the hall was organized by Sir Lawrence Bragg, at the Royal Institution, with the special co-operation of Prof. C. F. Powell and the United Kingdom Atomic Energy Authority in the Atom section, Prof. E. R. H. Jones in the Molecule section, and Prof. Alex. Haddow in the Living Cell section. The individual exhibits were arranged by scientists throughout the country with the help of many university and government laboratories and industrial organizations. Most of them were designed in general accordance with the standards recommended by Gunther Hoffstead.

The British exhibits in the Atom section include models of the Cockcroft–Walton laboratory, the 7-GeV. proton accelerator now being built at Harwell and the Harwell tandem generator. They also include a modern mass-spectrometer shown in comparison with a replica of the 1937 Aston mass-spectrograph from the Cavendish Laboratory, and an exhibit illustrating the discovery of mesons in cosmic rays. In the Crystal section they include accounts of the structures of collagen, deoxyribonucleic acid and vitamin B_{12}, determined by the methods of X-ray crystallography, together with a description of the tertiary structure of the protein myoglobin, also determined very recently by these methods. Also included are exhibits on neutron diffraction investigations, the growth of crystals and the nature of crystal surfaces and dislocations as they are observed directly by electron microscopy. In the Molecule section they illustrate polar molecules, electron magnetic resonance, chromatography, insulin, vitamin B_{12} again, reaction kinetics, conformational analysis and radiochemistry. The British exhibits in the Living Cell section include accounts of proteins, cell division, 'lamp brush' chromosomes, the human chromosome number, the function of deoxyribonucleic acid, radiobiology, the structure of viruses, the malaria parasite, the mechanism of muscle contraction, the fine structure of *Amoeba proteus* and the effects of vitamin A on cells grown in tissue culture. The film programmes shown daily in the small cinemas include a high proportion of British films on loan for the duration of the exhibition from a number of laboratories, film libraries and film makers.

The International Science Hall has now been open to the public rather more than two months and a large number of people have visited it. Many of them agree that although it is more than usually successful in presenting science at a popular level, it is most successful as a science exhibition for scientists. Visitors who have had no scientific training are often overawed by the scope and complexity of the exhibits, despite the many ingenious efforts that have been made to explain them. The people likely to profit most from visiting the Science Hall are undergraduate scientists and specialists, who will find there a review of the latest research in physics, chemistry and biology provided by leading authorities in each subject, and also a striking demonstration that science is best learned as a whole rather than divided into separate subjects that become increasingly less self-contained as knowledge advances. The exhibition closes on October 19.

D. C. PHILLIPS

ANTARCTIC RESEARCH

THE idea of holding an informal symposium on Antarctic research in New Zealand during February 1958, following the relief of Antarctic stations, was first discussed by the members of the United States and New Zealand National Committees for the International Geophysical Year. Conceived as a meeting between American and New Zealand field scientists, its scope was broadened at the 1957 Paris conference to include all nations with a working interest in the Antarctic. The confluence of several expeditions at Wellington was rather demanding in view of the exigencies of Antarctic operations but, through the goodwill of all and some sacrifice on the part of many, about seventy scientists from

Australia, France, Great Britain, New Zealand, South Africa, the United States and the U.S.S.R. were able to attend the meetings held in Wellington during February 18–22.

The participants were welcomed to New Zealand by the Prime Minister (the Right Hon. Walter Nash, P.C.) at a morning reception. Mr. Nash expressed the hope that future Antarctic research would take place "in the spirit of the International Geophysical Year". Business meetings of two types were arranged: the general meeting, at which informal papers would be presented; and the discussion meeting, mainly confined to the round-table conference of specialists. A considerable number of visiting and New Zealand scientists attended the latter meetings to listen to the discussions. Each meeting was presided over by a worker in the subject, and because of the informal nature of the symposium no attempt will be made to present the full proceedings.

The first meeting, devoted to "Special Investigations in Glaciology", had as its chairman Dr. J. Zumberge (United States). So much material was available on this subject that a whole day was devoted to it. Dr. T. Pewe (United States) outlined his summer's work on the glaciological history of McMurdo Sound, mourning the fact that the terminal moraines, from which a good deal of the history can be read, lie on the sea-bottom. Apart from two late Pleistocene glacial advances, there is evidence of a much older and more extensive advance of the Antarctic ice cap into McMurdo Sound, which covered all the valleys in the area and filled the Sound itself with glacier ice. Questions concerning the synchronism of Antarctic glacial cycles with other regions will probably best be answered by carbon dating of the samples collected from the deltaic beds in the ponds of the Ferrar and Koettlitz Glaciers. Periglacial processes on Antarctic rocks between 50° E. and 170° E. were described by Prof. K. K. Maarkov (U.S.S.R.). The physical and chemical weathering processes are similar to areas such as the cold, highland deserts of Asia as well as northern and western Greenland, the dominant factors being long duration of solar radiation, low humidity and low temperatures. Solifluction is observed but is feeble. The techniques of obtaining ice cores, developed in Greenland, were applied to a borehole at Byrd Station, which reached a depth of 1,013 ft. The Failing 1500 rig was operated by three men and 98 per cent of core was recovered, a remarkable achievement. The bottom layer is of the order of 700 years old, there being an average annual accumulation of 20 cm. water equivalent. E. W. Marshall (United States), after describing these efforts, gave a detailed list of temperatures and densities. More primitive methods were used by R. Cameron (United States) at an inland base 50 miles from Wilkes Station, where a pit 2 m. square was dug to a depth of 35 m., an auger hole being drilled a further 27 m. Stratigraphy, density and sastrugi patterns were investigated. At a depth of 33 m. a tunnel 2 m. in diameter and 6 m. long was excavated to study deformation. The average annual accumulation was 15 cm. water equivalent. A comprehensive account of the detailed Soviet studies on the movement, mass economy, heat balance, temperature regime, form and thickness, snow cover and alimentation of the Antarctic ice sheet was given by Prof. P. A. Shoumsky (U.S.S.R.). The east Antarctic ice sheet has a complex irregular form conditioned by sub-glacial relief; on the whole, it probably approximates to a flattened ellipse with irregularities introduced by the topography of the bedrock.

Deformation of the Ross Ice Shelf produced by the presence of Roosevelt Island was the subject of a special study by a team led by Dr. J. Zumberge. An extensive grid was surveyed during the past summer, and by repeating the survey in the summer of 1958–59 it is hoped to measure the rate of strain in various directions. Use was also made of dial strain gauges to measure the change in width of crevasses. Ice structures resulting from compression, tension and shear are all present in the area. The Ross Ice Shelf is between 230 and 290 m. thick around Little America, 300 m. thick off Minna Bluff and 420 m. thick near the Beardmore Glacier, being still afloat in the latter position, according to H. Bennett (United States), a member of the Ross Ice Shelf traverse party which covered 1,440 miles over the Shelf during the past summer. Seismic shots every 30 miles were supplemented by gravity and magnetic observations and glaciological pit work. The thickness of the ice and the depth of the bottom of the Ross Sea were obtained by using the measured travel-time for reflexion from the sea bottom and assumed velocities for ice and water.

B. Imbert (France) was chairman at the second meeting, on "The Topography of the Sub-Glacial Continent". At this meeting the provisional results of all traverses except that of the United States party to the Weddell Sea were presented and techniques discussed, even though at the time of the symposium some traverses were not quite completed (Fig. 1). Considerable geographical discoveries were made by the Byrd Station traverse party and during the support and reconnaissance flights. From the Ross Ice Shelf–Rockefeller Plateau boundary to the end of leg 1 (76° 30′ S., 113° W.) the ice–rock interface is rough, the thickness of the ice varying between 600 and 2,700 m.; all but a few peaks of the rock floor are

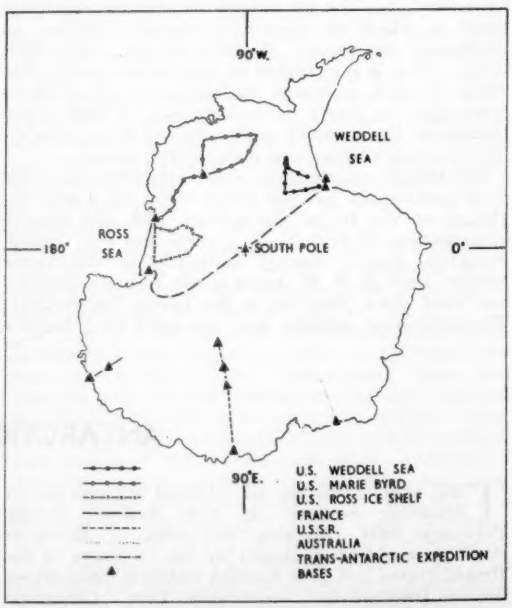

Fig. 1. Antarctica, showing major scientific traverse routes (1957–58)

at present below sea-level, the major portion far enough below to be under water if the ice were removed and the land allowed to rise into isostatic balance. Leg 2 shows quite a different picture, with a smooth bottom, great thickness of ice (from 2,300 to more than 3,500 m.), and broad gravity anomalies. Near the middle of the leg the rock floor reaches a depth of 2,000 m. below sea-level at a point where the elevation of the surface is a little more than 1,500 m. Leg 3, south-west from the Sentinels (77° 30′ S., 89° W.) was in a still different type of area—the rock floor being very rough and mostly above sea-level, breaking the ice surface in several places to form nunataks. This evidence indicates, subject to further examination of rock samples, that the Sentinels structure extends south-west at least as far as 80° 30′ S., 98° W.

The results of the Soviet, Australian and French radial profiles in East Antarctica showed some similarity, that is, complexity of land topography, mainly above sea-level except near the coast, but with great thicknesses of ice as high altitudes were reached. Dr. F. Jacka (Australia) noted the successful use by the Australians of a powered auger which enabled them to lay charges at depths of 30 m. There was agreement among all speakers that a small charge detonated at as great a depth as possible contributed greatly to good seismic records. G. Pratt, seismologist with the Trans-Antarctic Expedition, forwarded his preliminary results from Southice to Midway depot (81° 30′ S., 146° 09′ E.). On the Weddell Sea side of the South Pole the land surface is typically 1,000–3,000 ft. above sea-level and probably never below it; several ridges rise to a maximum of 7,000 ft. Twenty-five miles either side of the Pole the ice is very much thinner than at the Pole itself, and on the Ross Sea side remains thin, occasional crevassed areas being apparently on top of peaks covered by only 1,000 ft. of ice. The seismic results are generally confirmed by gravimetric data, but inaccuracies of the free air corrections weakens this support. American traverse parties endeavoured to minimize the effect of changing atmospheric pressures on elevations by leap-frogging. Considerable interest was shown in the experiences of the airborne seismic and glaciological unit under Dr. J. C. Cook (United States) operating from McMurdo Sound. Seismic soundings, gravity readings and glaciological studies were made at three stations on the plateau west of the Royal Society Range. At one of these stations the aircraft remained on the ground, while at the other stations the aircraft returned to base during observations. The seismic soundings were not very successful. Gravity deficiencies of more than 100 mgal. below McMurdo pendulum station were obtained, assuming ice to sea-level. A negative anomaly of similar magnitude is reported from the South Pole.

Dr. H. van Loon (South Africa) took the chair at the session on "Meteorology", which was opened by R. Taylor (United States) with an account of the work of Weather Central and the complex communication and reporting network which supplies information to Little America. Commander J. Mirabito (United States) recalled the great difficulties of operational forecasting in the Antarctic during 'Deepfreeze' I and II before the reporting network got into stride, when long-range flights were made on forecasts using data from McMurdo Sound supported by a few scattered ships. Air operations, however, have never been hampered by strong winds, and Commander Mirabito could only recall one incident involving aircraft icing during polar flights. I. Kerr (New Zealand) pointed out that with the present reporting network, Antarctic weather data are available to mid-latitude forecasters, but so far they have made little improvement in the effectiveness of New Zealand forecasting. Any improvement would be through a better knowledge of general atmospheric circulation and processes resulting from Antarctic studies. In common with other meteorologists in the southern hemisphere, he emphasized the large oceanic gaps in reporting centres, which only weather ships could fill. Forecasting of gales at a station where synoptic data were not available was discussed by Dr. J. Shear (United States). Changes in pressure were of little use, and though cloud sequences were classical and informative, Shear found that the most effective tool was a 'time-hodograph' of the wind vector at the 500-mb. level.

Soviet aerologists led by Dr. O. Krichek considered that the configuration of the Antarctic continent and particularly its northward extensions was responsible for six regions of stable high-pressure tongues. Reinforcement of these tongues blocks cyclones over the adjoining seas, and zones of stationary cyclones between these ridges occur in the Weddell Sea, off eastern Queen Maud Land, Mackenzie Sea, off Wilkes and George V Land, and in the Ross Sea. Ridges of the Antarctic anticyclones may connect with subtropical anticyclones, inhibiting zonal circulation, which is by no means exclusively typical in the southern hemisphere. Aerial reconnaissance for ice over the Davis Sea confirms that the cyclonic zones have a substantial effect on the position of the ice belt. At Mirny during the winter, inversions of up to 35° C. were recorded and often persisted, though down-slope winds reached a velocity of 40 m./sec.

Prof. H. Hoinkes (United States), who was chairman of the session on "Radiation", discussed the heat balance equation at Little America. He carefully measured or assessed the various factors: radiation balance, turbulent exchange, latent heat change, precipitation exchange and conduction from below. Latent heat, precipitation exchanges and conduction from below are not significant. Winds and temperatures measured at several levels up to a height of 17 m. show that turbulent exchanges are rarely of much importance at Little America. Thus, radiation balance is the only important term in the equation and this was studied with a Link–Fuessner solarimeter, Schultze net radiometer and an Ångström pyrgeometer. The lowest outgoing radiation recorded was 0·08 langley/min., but only occasionally was 0·06 langley/min. exceeded. Inversion in the presence of clear skies would decrease this to 0·02 langley/min. Summer albedos were remarkably high. At the South Pole the mean of 100 readings was 0·89 (range, 0·845–0·943); at Byrd Station 0·88, and at Little America 0·90 after fresh snow.

A unique and important part of the Soviet radiation programme, described by Dr. V. I. Shliakhov, was the measurement of the short-wave radiation balance at various altitudes. Special flights were made for this purpose. The great transparency of the Antarctic atmosphere undoubtedly accounts for the very low linear gradient of 0·0004 langley/min. per 100 m. up to 4,500 m. The figure for medium latitudes in Europe is 0·03–0·04 langley/min. per 100 m. The instrumental diversity in measurements of radiation made at Antarctic stations was very

apparent in discussion. Shliakhov used a Yanishevsky balance meter and attempted to protect it from wind and snow damage by shielding it with a polyethylene cover 20 μ thick. A minor parlour game was played of deriving the minimum possible surface temperature in Antarctic regions. Shliakhov gave − 80° C. ± 2° C., while Taylor preferred − 78° C. The lowest surface temperature recorded at the South Pole station during 1957 was − 74° C.

The chair for the session on "Oceanography" was taken by R. M. Cassie (New Zealand). The presence of the Soviet research ship *Ob* in Wellington during the symposium ensured a strong representation of Russian marine scientists. An account of the first two Antarctic cruises of *Ob* (1956 and 1957) was given by Prof. V. Kort. During these two cruises 329 oceanographic and 225 geological stations were occupied, mainly in the Indian sector of Antarctica. About 150 cores 2·0–5·5 m. long have been taken by a gravitator tube, and five cores of 16 m. have been taken by a piston corer. The present cruise is charged with similar investigations in the Pacific sector of Antarctic waters. From continuous echo soundings and cores, Dr. A. V. Jivago (U.S.S.R.) was able to discuss the types of bottom relief in the southern Indian Ocean and east Antarctic seas. Extremely complicated volcanic relief covers approximately two-thirds of the area explored. Besides the known volcanic chains extending from the Atlantic Ocean across the Crose plateau to the Kerguelen–Gauss range, big sub-surface volcanoes have been discovered to the west of Heard Island and north-west of the Prince Edward Islands. Their relative heights reach 3,000 m. Vast areas consist of lava plains with stepping, hilly and block surfaces. The Antarctic Shelf, which represents the most complicated type of relief, was investigated in more detail. Its boundary is considerably deeper than other continents (500 m. or more), the surface is often rough and in some places devoid of covering sediment. Several morphological sub-types have been distinguished within the Shelf limits.

According to Dr. A. P. Andriashev (U.S.S.R.), who described the ichthyological investigations of *Ob*, 1,100 specimens representing 75 species and 16 families have been caught. In the shallow water of the eastern Antarctic continent, trematoms and *Gymnodraco acuticeps* are the most abundant species, and some of these, especially *T. bernacchi*, may have some fishing importance to wintering-over parties. New types of chænichthyid and harpagiferid fishes were found among fishes caught by trawls at depths between 100 and 3,000 m. Eight more species of the white-blooded chænichthyidae were added to the five already known. Qualitative investigations of the bottom and plankton invertebrates have shown the extremely low productivity of food forms (for fishes) of the bottom fauna, in comparison with the rich development of the pelagic crustaceans, substantiating Nybelin's hypothesis concerning the cause of partial transition of many bottom notothenioid fishes to pelagic feeding habits. The factors governing the character of bottom fauna of the shelf are the great depth of the boundary, complicated relief, extremely poor sorting of bottom sediments, and strong bottom currents which carry the subsiding detritus away to the ocean. Consequently, an extremely rich and varied fauna of sponges, cœlenterates, bryozoans, brachiopods, ascidians and an impoverished fauna of crustaceans and molluscs are characteristic of the Shelf. One of the main differences between the Shelf faunas of Antarctica and that of other areas is that the polymixtous nature of the former makes it very difficult to ascertain the leading species.

Dr. R. W. Burling (New Zealand) exhibited a vertical section of isotherms south of New Zealand, in which tongues of cold water are present in positions suggesting the existence of a large horizontal eddy. Such eddies would have a great influence on mixing between various water masses in their predominantly eastward flow. The theoretical model of the Antarctic circumpolar current propounded by Hidaka and Tsuchiya, in fact, requires an occurrence of such eddies.

Dr. T. Hatherton (New Zealand) was chairman of the session on "Seismology". Epicentres within the Antarctic area were reported only by Scott Base (including tremors from Erebus) and Halley Bay, although stations along the coast of East Antarctica report a plenitude of seisms from the Indian Antarctic swell. Both d'Urville and particularly Scott Base reported remarkable changes in microseismic activity, very low in winter, very high in summer, presumably related to the effect of pack ice on the generation or transmission of microseismic energy. The successful operation of seismographs on floating ice (Halley Bay) and inland *névé* (South Pole and Byrd) was of considerable interest.

The chair for the meeting devoted to "Biology" was taken by Dr. R. A. Falla (New Zealand). Observations made on the Byrd traverse were summarized by Dr. D. Hale (United States). Eleven snow petrels and twelve skua gulls were sighted at distances more than 300 miles from the coast. A penguin track was discovered at 77½° S., 99° W. at an altitude of 1,260 m. The track was followed for more than a mile and traces of urine and fæces obtained. More than sixty specimens of lichens were collected; the entire collection with possibly two exceptions seems to be composed of species previously undescribed. *Umbelicaria* is noticeably absent and there is no *Usnea* sp., which is present all along the coast of Antarctica. *Lecedia* sp. and *Buellia* sp. predominate, as might be expected, and *Alectoria* sp. seems fairly widespread. In the Sentinel Mountains area individual nunataks, though fairly close in location, may have rather different floras. Flora affinities seem to be with the lichens of the west coast rather than with those of the Edsel Ford Mountains.

Dr. K. A. Brodsky (U.S.S.R.) has examined the mass development of phytoplankton in the cold waters near the continent, and along sections on the 90° E. and 78° E. meridians, with the northern boundary near 63° S. Zooplankton was poor in waters rich with phytoplankton, but increased to the north. The biomass in the northern regions did not exceed 0·75 gm./m.³, whereas in the phytoplankton zone there was not less than 1 gm./m.³, sometimes reaching more than 7 gm./m.³. In Antarctic waters the cold intermediate layer is not impoverished, but is somewhat richer in plankton than the superficial one. Brodsky considers that the term 'Sub-Antarctic', like 'Sub-Arctic', should be discarded for biogeographical purposes. He prefers a subdivision into 'Antarctic' (northern boundary between 60° S. and 52° S. for different areas), 'Notal' (northern boundary between 50° S. and 40° S.) and 'Tropical'. Brodsky proposes using the composition and distribution of the Celanoid to compare the biogeographical regions of both hemispheres. Data on bird-banding, seal-branding and other studies were exchanged, and

Pewe reported the discovery of 81 carcasses of crab-eater seals at altitudes of 1,000–2,000 ft. in the foothills of the Prince Albert Mountains.

Dr. F. Jacka (Australia) occupied the chair at the session on "Aurora". Interest centred mainly on radio echoes and the problem of relating them to visually observed auroras. At Invercargill, all-sky camera and very high-frequency radio-echo equipment have been run continuously. M. Gadsden's (New Zealand) analysis of six months results showed that the probability of aurora being present at the same time as radio echoes increases with increase in local *K*-index, suggesting that there is no intimate connexion between visual aurora and radio echoes. Radio echoes show a broad maximum in occurrence at local midnight (35 per cent) and a minimum shortly before local noon (3 per cent), whereas no significant diurnal variation has been detected in the occurrence of visual auroras. The echoing region heights average 110 km. and, with the radar looking south, radial velocities are generally inward (that is, northward) before local midnight and outward (southward) after, with an average north/south radial velocity of 400 m./sec. K. Bullough's (France) measurements at d'Urville (geomagnetic latitude 75·5° S.) showed that diurnal distribution of echoes displays a very sharp peak in the evening in winter with more even occurrence throughout the day in summer. The echoes occur almost entirely to the north during the winter months, with a marked increase in activity to the south in summer. Skip echoes are believed to have been observed on three occasions. Analysis of the d'Urville results is not yet sufficiently advanced to permit correlation with visual activity. All stations reported little success with spectrographs. Many observers commented upon poor design and engineering features which restricted the operation of their instruments. Little discussion was possible on visual auroral observations at Antarctic stations as the results have not yet been reduced.

The closing session was devoted to "Future Research in the Antarctic", with Dr. G. de Q. Robin (Great Britain) in the chair. Seven speakers discussed future work in their respective fields. Dr. F. Jacka, dealing with the physics of the upper atmosphere, requested more studies of 'whistlers' and the 'dawn chorus', which have hitherto been almost entirely neglected. He also suggested a better geographical distribution of cosmic ray stations, which are at present concentrated around the coast of the African–Australian quadrants. Spectrographic studies of the aurora have been less successful than expected. Simpler instruments with more limited objectives might be preferable for future work. B. Imbert, speaking on ice cover and glacial relief, reviewed the achievements of the past year in seismic sounding, and came to the conclusion that tractor trains with close air support, using mechanized drilling techniques to place a small charge as deep as possible below the surface, form the most desirable unit. The high plateau of east Antarctica offers the severest challenge. There was some discussion on the use of radio waves for soundings of the depth of ice, but in the absence of confirmed experiments using these techniques, normal seismic methods must continue to be used. The use of the triangular traverse was urged, as being more informative and easier to support. Prof. Shoumsky, dealing with general glaciological problems, outlined possible future Russian traverses, but urged that attention be paid to general ice regime, heat- and mass-balance as well as to form and dimensions. The morphology of the huge ice streams of the continent is an especially desirable study, but one of considerable difficulty because of the broken and crevassed nature of the boundaries. With regard to meteorology, R. Taylor considered that it is now possible to obtain a reasonable representation of the mean circulation over the Antarctic, but a comprehensive picture of southern hemisphere circulation is impossible in the foreseeable future, because of the lack of information over the southern oceans. He endorsed the use of weather ships, as did many other speakers at the symposium. As a by-product of Antarctic work, he predicted considerable improvement in many instruments. Meteorological flights have not been used as often or extensively as they should. Prof. V. G. Kort summarized comprehensively the needs of oceanographic research over the next ten years. In particular, he pleaded for much more concentrated work in zones of convergence and divergence, and in coastal waters an extension of hydrological work at coastal stations, where remarkably few oceanographic studies are done, and comprehensive studies of the pack ice by monthly flights from coastal bases. Actinometric studies have been successfully carried out this season on *Ob* and offer considerable scope in the future.

Dr. R. A. Falla considered that biological studies in the Antarctic had benefited during the International Geophysical Year although they were not planned explicitly, except in the case of the larger vertebrates, where banding and branding studies had been successfully carried out. Amateur observers could do valuable preliminary studies in biological fields, which could be examined to see where professional studies were required. He cited as an outstanding example the collection of lichens from the Marie Byrd Land mountains by the Byrd traverse party. Intensification of taxonomic, ecological and physiological studies was required. Biological research suffers from inadequate national and international organization, and this must be remedied before Antarctic biological research can achieve the same effectiveness as that in the physical sciences. Falla ended with a plea for the greater participation by mature scientists in expeditions, thus emphasizing a weakness in most British Antarctic teams, which rely unduly on the efforts of young graduates.

Dr. T. Hatherton, speaking on the future of crustal geophysics, emphasized the need for precise levelling to the main inland bases. Antarctic seismic activity appears to be present only in the areas of the Ross and Weddell Seas, and determinations of epicentres require at least two stations. He suggested that such dual stations (less than 100 km. apart) might be useful also for gradient and movement investigations in the upper atmosphere, though Jacka preferred dispersion of the stations in ionosphere studies. Seismic and magnetometer work at sea in the areas of most structural interest were recommended. Geology needs no specific recommendations but should be carried out wherever exposures are available. Dr. Robin closed the meeting by pointing out that the best contribution that scientists attending the symposium could make to future research was to work up their results as soon as possible, before new interests and opportunities arise to distract them from completing their Antarctic work by its final publication.

T. HATHERTON

NOMENCLATURE OF ROCK UNITS IN THE ROSS SEA REGION, ANTARCTICA

By Dr. H. J. HARRINGTON
New Zealand Geological Survey

A MEETING of ten British Commonwealth geologists who had worked in Antarctica with the Trans-Antarctic Expedition, the New Zealand Ross Sea Expedition, the New Zealand Geological Survey Expedition and the Falkland Islands Dependencies Survey, was held in Wellington in March to exchange information gathered in recent seasons. It became clear that communication of results is hampered by an almost complete lack of a formal nomenclature for rock units of the Ross Sea–Weddell Sea region, the rocks being described, except in the case of the Beacon Sandstone, as 'the Dolerites' or 'the Schists and Marbles' and so on. A nomenclature for the major regional units was devised at the meeting for use in forthcoming publications and maps and, as there are no international arrangements for this matter, it is set out below with explanatory notes. It should help to prevent the confusion that could arise if different nomenclatures were proposed by geologists of expeditions now scattered in several homelands. In devising it, the meeting had as part of its background a knowledge of some of the recent work by United States and Soviet geologists described at an earlier meeting held in Wellington in February.

Quaternary	Moraines, beaches, etc.
Upper Tertiary and Quaternary	McMurdo Volcanics
? Jurassic or Cretaceous	Ferrar Dolerites
Palæozoic and Mesozoic	Beacon System
Lower Palæozoic or Precambrian	Admiralty Intrusives
Lower Palæozoic or Precambrian	Ross System

McMurdo Volcanics (*Group*). This term is proposed for the volcanic rocks of Quaternary and possibly Upper Tertiary age in the Ross Archipelago and other islands in the Ross Sea, the Balleny Islands and Scott Island, and parts of the coast of Victoria Land. The unnamed volcanic rocks of Marie Byrd Land are tentatively excluded. The name 'Ross Volcanics' is not used, to avoid confusion with the volcanic rocks of James Ross Island (Graham Land).

Ferrar Dolerites (*Group*). Dolerite sills and dykes occurring abundantly in the Beacon Sandstone in the Ferrar Glacier district and other parts of Victoria Land, and also in the Beacon System in Adelie Land, and elsewhere, are called the Ferrar Dolerites. Several geologists at the meeting considered that the dolerites of Adelie Land and elsewhere should be distinguished within the group by regional formation names from the type Ferrar Dolerites (Formation) of Victoria Land.

Beacon System. The Beacon Sandstone was named by Ferrar from its occurrence at Beacon Heights in Victoria Land. Similar sandstone and associated sediments occur widely in far distant regions in Antarctica and have either been called Beacon Sandstone or compared and correlated with it. It was the opinion of the meeting that all occurrences could be classified together as Beacon System, that the type rocks in Victoria Land could be called Beacon Sandstone (Group), and that local group names might be appropriate at present in other regions.

Admiralty Intrusives (*System*). The system consists of pre-Beacon intrusives, predominantly granite and granodiorite, in the Ross System. The type rock is the Tucker Granodiorite (new name) of the Admiralty Mountains in northern Victoria Land. The granitic and granodioritic rocks of the McMurdo Sound region are included, as well as, tentatively, those of Marie Byrd Land.

Ross System. The pre-Beacon sediments and metamorphosed sediments so far described from the Ross Sea region are unnamed marbles, schists and associated rocks occurring in Victoria Land from Terra Nova Bay southwards through the Royal Society Range, the 'slate-greywacke formation of Robertson Bay', and unnamed thick 'greywacke'-type sequences of sandstone and shale in Marie Byrd Land. In addition, occurrences of limestone containing *Archaeocyathinae* are known in the Beardmore Glacier district, and seem to be extensive in the Weddell Sea region.

Recent field work has shown that the Admiralty Mountains of northern Victoria Land consist mainly of an assemblage of quartzose greywacke and argillite, meta-greywacke and meta-argillite, schist and some metamorphosed limestone which is being called Moubray Group (new name) and almost certainly includes the 'slate–greywacke formation of Robertson Bay'. Inspection of aerial photographs shows that this group extends south of the Admiralty Mountains towards Wood Bay and Terra Nova Bay. Farther south, rocks of closely similar lithology are associated with marble and schist in the McMurdo Sound region. It is suggested that all these rocks in Victoria Land may be called Ross System, the type beds being those of the Moubray Group. The rocks of the Ross System in Victoria Land give the impression of being the deposits in a major geosyncline in which the shelf sediments with carbonate rocks were deposited in the McMurdo Sound district and southwards, and the deeper-water sediments with few carbonate rocks were deposited in northern Victoria Land.

The sediments of the Moubray Group strike east-south-east into the Ross Sea and towards the very thick greywacke-type assemblages striking north and north-west of the Edsel Ford and Rockefeller Mountains in Marie Byrd Land. Several geologists at the Wellington meeting considered that this is reasonable evidence for tentatively including the Marie Byrd Land assemblages in the Ross System, though distinguishing them by the names Edsel Ford and Rockefeller Groups. If this is done, the only known pre-Beacon sedimentary rock of the lands surrounding the Ross Sea that is not included in the Ross System is the limestone of the Beardmore Glacier–Weddell Sea region that in at least one place contains *Archaeocyathinae*. It seems that its classification must await further work.

OBITUARY

Prof. J. K. Robertson

JOHN KELLOCK ROBERTSON, professor emeritus of physics in Queen's University, Kingston, Ontario, died suddenly in London on June 24.

Robertson came to Queen's as a lecturer in physics in 1909. He had entered the University of Toronto on a classics scholarship, but took his degree in mathematics and physics and spent two graduate years as demonstrator in physics. Except for two interludes of a year each, he remained at Queen's until his retirement from his posts as professor of physics and head of the Department in 1951. The session of 1912–13 he spent at the Cavendish Laboratory, Cambridge, and as a member of Emmanuel College. During 1933–34, he was a visiting professor at the Imperial College of Science and Technology, London.

As a physicist, Robertson's major interests were in the fields of optics and of X-rays and radiology. His text-book, "Introduction to Physical Optics" (1929), has run through successive editions, as did his "X-Rays and X-Ray Apparatus" (1924) and his "Radiology Physics" (1941).

He was an enthusiastic, patient and lucid teacher. His most distinctive courses of lectures were those which he gave to medical students. He was able to persuade his medical colleagues that the study of physics should be continued through two years, allowing more extensive work than was usual in North American medical schools. He was greatly pleased when the members of the last medical class which he taught made him an honorary life member of the class. His interest in medical physics continued after he gave up teaching, and he was an honorary member of the British Institute of Radiology and of the Association of Hospital Physicists.

He was elected Fellow of the Royal Society of Canada in 1926, was president of Section III in 1942–43 and president of the Society in 1944–45. After his retirement, when he spent at least part of each year in London, he represented the Royal Society of Canada and the National Research Council at a number of international gatherings.

Robertson was a literate physicist with a wide range of interests and friends. He had a talent for explaining physics to the layman ("Atomic Artillery and the Atom Bomb", 1945) and an active interest in literature.

He was a fourth-generation Canadian, born in 1885, in Perth, Ontario, which had begun as a Scots settlement some sixty years earlier. In 1932 he published a charming little book, "Sketches of Tayville", which had appeared earlier in the *Queen's Quarterly*, and which recalled his boyhood in a Scottish-Canadian town.

'J.K.' was a man of warm friendships and strong loyalties. He had a contagious enthusiasm for learning and scholarship. His gallantry turned what might have been a lonely retirement into a lively enjoyment of friendships and intellectual interests. He is gratefully remembered by former students and colleagues, by his brothers in the craft and by many friends on both sides of the Atlantic.

W. A. MACKINTOSH

NEWS and VIEWS

National Standards Laboratory, Sydney: Mr. N. A. Esserman

MR. N. A. ESSERMAN, chief of the Division of Metrology, has been appointed as the first director of the Commonwealth Scientific and Industrial Research Organization, National Standards Laboratory, Sydney. This appointment is one of the first consequences of the recommendations of a committee of the Advisory Council which reported last year on the future development of the National Standards Laboratory. Mr. Esserman was born and educated in Sydney, graduating in science with honours at the University of Sydney in 1916. Following a period during and after the First World War at the Arsenal Branch, London, he returned to Australia to join the Commonwealth Department of Defence, later becoming senior physicist, Munitions Supply Laboratories, at Maribyrnong in 1929, and assistant superintendent of laboratories in 1938. During this time, Mr. Esserman had accumulated a wide experience of metrology and general physical instrumentation and their application in the engineering industries. He was therefore well situated to assume the task of developing the newly created National Standards Laboratory when he was appointed senior officer-in-charge of the Metrology Section in 1939. Mr. Esserman took a major share in piloting this young establishment through the turbulent years of the Second World War. The virile engineering industries which have grown to maturity in Australia in the post-war years owe a great deal to the knowledge and experience which Mr. Esserman brought to his labours at the National Standards Laboratory. He also undertook, during the War, a number of other tasks associated with the general effort of munitions production in Australia. He was a member of the Optical Munitions Panel, the Australian Council for Aeronautics, and the Optical Advisory Panel of the Department of Post-War Reconstruction. Mr. Esserman is an active member of many scientific institutions in Australia, having held office as president of the Royal Society of Victoria, Fellow of the Australian National Research Council, chairman of the New South Wales Division of the Australian Branch of the Institute of Physics, trustee of the Sydney Museum of Applied Arts and Sciences, and member of the Technical Education Advisory Council and the International Committee of Weights and Measures. Mr. Esserman will retain his responsibilities as chief of the Division of Metrology.

Dr. G. H. Briggs

DR. G. H. BRIGGS, who is retiring as chief of the Division of Physics of the National Standards Laboratory, graduated in 1916 at the University of Sydney and was appointed lecturer and later assistant professor of physics at that University. His Ph.D. degree was gained in research in association with

Lord Rutherford at the Cavendish Laboratory. At this time and in subsequent research he made notable contributions in the accurate determination of the fundamental constants of nuclear physics, obtaining his D.Sc. degree in 1937. He joined the National Standards Laboratory of the Commonwealth Scientific and Industrial Research Organization at its inception in 1939, being appointed as officer-in-charge of the Physics Section, which became a Division in 1945. Under Dr. Briggs's guidance the Division has not only established a high reputation for research in the physical sciences but has also been of great assistance to manufacturing industry in Australia during its rapid growth during and after the Second World War. Dr. Briggs was scientific adviser to the Australian delegation to the United Nations Atomic Energy Commission during 1946–47; president of the Australian Branch of the Institute of Physics in 1950; and chairman of the Unesco Australian Committee for Natural Science during 1953–55.

Dr. R. G. Giovanelli

Dr. R. G. Giovanelli, who is to be appointed chief of the Division of Physics of the National Standards Laboratory in succession to Dr. Briggs, graduated in 1937 at the University of Sydney, was Research Fellow at the Commonwealth Solar Observatory, and after a short period on the staff of the Sydney Technical College, spent a year at the National Physical Laboratory, Teddington, before joining Dr. Briggs's staff at the National Standards Laboratory. He received his D.Sc. degree at the University of Sydney in 1950 for his studies on the physics of the solar atmosphere. Dr. Giovanelli is a Fellow of the Royal Astronomical Society, and was awarded the Edgeworth David Medal of the Royal Society of New South Wales in 1949. Dr. Giovanelli's main research interests have been in solar physics, the fine structure of the Sun's outer layers, solar activity and spectra, and the emission of radiation from high-temperature atmospheres.

Director of Fire Research : Mr. D. I. Lawson

Mr. D. I. Lawson, who has been appointed director of fire research of the Joint Fire Research Organization of the Department of Scientific and Industrial Research and the Fire Offices' Committee, is forty-seven. He was born in Sheffield and educated at Woodhouse Grammar School. After taking first-class honours in physics with mathematics at the University of Manchester and obtaining an M.Sc. degree for research in X-ray crystallography, he became a lecturer in physics and telecommunications at Woolwich Polytechnic in 1934. Five years later he became head of the Research Division at Pye, Ltd., of Cambridge. Mr. Lawson joined the Fire Research Station at Boreham Wood, Herts, in June 1948, since when he has specialized in problems of heat transfer and the ignition of materials. Since 1952 he has been assistant director to Mr. S. H. Clarke, whom he succeeded on August 1. Mr. Clarke has been appointed director of the Warren Spring Laboratory of the Department of Scientific and Industrial Research (see *Nature*, 182, 225; 1958), which is being built at Stevenage.

National Science Foundation : Dr. R. M. Robertson

Dr. Randal M. Robertson, who has been appointed to the staff of the National Science Foundation as assistant director for mathematical, physical and engineering sciences, was born in Tampa, Florida, and graduated in mathematics and natural philosophy at the University of Glasgow and received a Ph.D. in physics from the Massachusetts Institute of Technology. He taught briefly at both institutions before serving as a research assistant at Columbia University. During 1937–42 he was a research associate with the Norton Company in Worcester, Massachusetts. During 1942–46 he was on the staff of the Radiation Laboratory at the Massachusetts Institute of Technology. In 1946 he went to Washington as head of the Mechanics and Materials Branch of the Office of Naval Research. In 1948 he became director of the Physical Sciences Division, and has been director of the Research Group since 1952. He has conducted research on arc-cathode phenomena; nuclear magnetic moments; physics of solid materials, especially abrasives and refractories; and microwave linear-array scanning antennæ.

British Scientific Attaché in Moscow

In reply to further questions in the House of Commons on July 1 regarding the grading of the post of British Scientific Attaché in Moscow as principal scientific officer instead of deputy chief scientific officer as in Washington, Mr. H. Nicholls, Parliamentary Secretary to the Minister of Works, as representing the Lord President of the Council, repeated what was said on June 17 and 24, namely, that if a suitable candidate could not be found, the grading would be reconsidered. There was no question of wanting to have a higher grade officer in the United States than in Moscow. The immense interchange of knowledge with the United States has justified the team of men with the higher grade there, and when there is any likelihood of getting the same co-operation in Moscow the matter will be reconsidered. Appointment of a higher grade scientist was not excluded; but in opening the new service, the manner of approach rather than scientific qualifications was the more important.

Plutonium from Civil Nuclear Power Stations

An adjournment debate in the House of Commons on July 11 on a motion of Mr. A. Palmer's on the use of nuclear power stations constructed under the civil programme of the Central Electricity Generating Board for the production of military plutonium elicited a sharp reply from the Parliamentary Secretary to the Ministry of Power. Sir Ian Horobin repeated the specific assurance that all the capital costs of the civil stations will be met and it is the firm intention of the Government, the Atomic Energy Authority and the Central Electricity Authority, in fixing the prices at which the fuel rods will be bought back, to take account of any additional operating costs incurred in neutralizing them. Sir Ian said that a vital part of the economic calculations of the competitive position of nuclear power stations depends upon the number of megawatt-days per ton of uranium obtained from a uranium slug. It should not be taken that any of the slugs in any of the reactors, whether they required modification or not, will remain in the piles for a time different from that under the original programme. Information on high irradiation is required and we cannot wait for developments at Hinkley Point, which is not yet in operation; there is nothing to stop certain elements being left in the Generating Board's reactors to see if they can be burnt to the desired length. For the export trade we are simply concerned with the prices

at which the slugs will be sold and bought back, and Sir Ian thought the overseas purchasers may well prefer to get rid of their slugs at a short rate of irradiation rather than otherwise. That price must be settled as part of the contract, and in conclusion Sir Ian, pointing out that the changes are marginal and that plutonium is produced initially in this type of reactor, emphasized that the costs on the defence side must be incurred anyhow, and expressed the hope that no suggestion would get abroad that we are making fundamental changes in these reactors and hinder the development of a promising and vital civil nuclear programme.

Developments in Nuclear Energy

In a written answer in the House of Commons on July 14, Sir Ian Horobin, for the Minister of Power, stated that the Safety Branch of the Atomic Energy Authority is being strengthened in accordance with the recommendations of the Fleck Committee, and the Government is preparing legislation to implement the policy of licensing and inspection which he had outlined on February 10. Also in a written answer, the Prime Minister said on July 15 that experimental work on thermonuclear fusion at the Atomic Weapons Research Establishment at Aldermaston is directed towards a better understanding of the mechanism by which high gas temperatures can be achieved. The encouraging results to date do not alter earlier predictions about the probable time-scale of the development of thermonuclear power. The Atomic Energy Authority is recruiting some additional staff for this work. Replying for the Prime Minister on July 17, Mr. R. A. Butler said that the agreement under negotiation with the Euratom Commission is likely to contain provisions similar to those in the agreement with the Italian Government, which provide for the supply of fuel by the United Kingdom and for assistance in the manufacture of fuel elements in Italy in due course. The role of the Euratom supply agency is a point to be taken into account in these negotiations and the Commission has given assurances that it does not intend to erect any obstacles to the development of nuclear power in its member countries. Pressed further on the point, Mr. Butler said he hoped that British technical contact with the Euratom Commission would be close.

Engineering Research

In an oral reply in the House of Commons on July 1, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that to get its research results across to members, particularly at the shop-floor level, the Production Engineering Research Association had developed an effective liaison and advisory service, on which one-third of its resources were spent. Short instructional courses on new production techniques were held in the Association's Melton Mowbray laboratories, which had been attended by about 1,650 persons during the past year, and a mobile unit had provided 150 practical demonstrations in members' works. About 3,000 technical inquiries were answered each year. He undertook to see whether the connexion between East Kilbride, engineering firms and universities in Scotland was sufficiently close. In reply to a further question, Mr. Nicholls said that for some years the Mechanical Engineering Research Laboratory had sponsored at universities, and itself conducted, research on heat transfer under various conditions of steam condensation and it had been demonstrated that condensation of steam on cooling surfaces as separate drops had great advantages in speed over normal film condensation. Chemicals had been developed which when applied to brass or copper surfaces produced this 'drop' condensation, and the method had been tried to some extent in industry. If it proved really successful the size of condensers would be halved.

Distribution of Industry

In introducing the Distribution of Industry (Industrial Finance) Bill, which was generally welcomed and received an unopposed second reading in the House of Lords on July 15, Lord Mancroft said that since the Distribution of Industry Act was passed in 1945 the pattern of unemployment in the country had changed. In some places in the development areas Government-financed factories were at present themselves providing work for nearly 200,000 people, apart from work provided by firms attracted to those areas without Government assistance; but in other places outside the development areas unemployment had become high and might remain high. The Government believed it was as important to assist those places as to assist the development areas, and accordingly the Bill proposed to extend the powers given to the Treasury under the present Act to make grants or loans to industry in the development areas to include places outside those areas where the Board of Trade was satisfied that the money would assist to reduce a high rate of unemployment which might otherwise be expected to continue. The Bill would also enable grants or loans to be made to undertakings engaged in trade or business as well as in industry, and Lord Mancroft explained that the Bill purposely did not define either the places or the undertakings which would be covered. This was to ensure the maximum flexibility, and Lord Mancroft said that banks, insurance companies, hire purchase companies, hotels and office organizations generally might be included. He undertook to look carefully into a technical point raised by Lord Conesford regarding the bearing of the Bill on the proper distribution of industry. Viscount Hall, in welcoming the Bill, quoted the Board of Trade estimate that expenditure on factory building of £70 million under the original Act over twelve years represented 90 per cent of expenditure under that Act and that loans had totalled £6,900,000.

Fuel Abstracts

Asked for a statement in the House of Commons on *Fuel Abstracts* on July 2, Mr. H. Nicholls, as representing the Lord President of the Council, said in a written answer that before deciding to discontinue *Fuel Abstracts* the Department of Scientific and Industrial Research consulted the Ministry of Power, the National Coal Board, the British Coal Utilization Research Association and other organizations. Careful examination showed that the various sections of *Fuel Abstracts* were covered wholly or in part by other abstracting organizations. Discussions have taken place with the National Coal Board as to ways and means of arranging for abstracting organizations in Britain to extend their present coverage and for the provision of some form of joint index. The Society of Chemical Industry is increasing the

coverage of abstracts within its field of interest, while the Institute of Fuel is considering the possibility of issuing collected abstracts of fuel literature. The Department had had arrangements with abstracting organizations which do not make their abstracts directly available to the general public, whereby abstracts of fuel literature could be published in *Fuel Abstracts*, and there was no reason to suppose that similar arrangements could not be made by any other organization which publishes collected abstracts of fuel literature.

International Geophysical Year: Meeting in Moscow

The fifth meeting of the Special Committee (C.S.A.G.I.) of the International Geophysical Year is being held during July 29–August 9 in the Moscow State University. The meeting is reviewing the achievements of the International Geophysical Year since its commencement on July 1, 1957, and also the scheme now in operation for the deposition and exchange of results between the three data centres set up for each of the International Geophysical Year disciplines. During the course of the meeting there will be many discussions of a technical nature concerning preliminary results, and in addition there will be a symposium lasting several days concerning the rocket and artificial Earth satellite programme. A meeting of the Special Committee for Antarctic Research set up by the International Council of Scientific Unions is to consider research programmes in the Antarctic region after the closing of the International Geophysical Year programme on December 31, 1958.

Tax Concessions on Subscriptions to Learned Societies

When the tax concessions to individuals on their fees and subscriptions to learned societies and professional bodies, contained in the Finance Bill, were debated in the House of Commons on July 17, objections were raised to the limitation of the concession to bodies which were "not of a mainly local character". Mr. J. E. S. Simon, Financial Secretary to the Treasury, explained that the Inland Revenue had already to examine the claims of some 3,000 national societies and to extend it to all the local bodies would involve an administrative task in which the benefit to individuals would be out of all proportion to the expense involved. He fully appreciated the claims of many local societies but insisted that the relief to the individual tax-payer had to be balanced against the cost to the general body of tax-payers. He undertook, however, to put the views expressed before the Chancellor of the Exchequer. Mr. Simon also said that it was not a condition of relief that the employer should stipulate membership of a professional body; it was sufficient that the registration should be a condition for the performance of the claimant's duties. The views of the employer were no longer relevant. He also added that the clause would not be construed narrowly by the Inland Revenue, but in a common-sense way, with a desire to help professional men who could bring themselves fairly within its terms.

Journal of Nuclear Energy

It has been announced that the *Journal of Nuclear Energy* is shortly to be issued in two parts (*A* and *B*) dealing respectively with basic reactor science and reactor technology. Part *A* will continue to be published monthly with little alteration and will consist of papers dealing with the scientific, biological and economic aspects of nuclear energy. Part *B* will be published quarterly and the first issue will appear in time for the Second Geneva Conference. It will be devoted to technological subjects contributing to the development of nuclear energy for peaceful purposes and will contain papers on mathematics (including computing for design purposes); applied physics; fuel processing and plant criticality; heat transfer; fuel element design and fabrication; and other scientific aspects of the construction and operation of nuclear reactors. The editors direct attention to three important characteristics of Part *B*: the international character of the journal; the high scientific and professional standard; and the short publication time. Both parts of the journal will contain translations of relevant papers published in the Russian journal of atomic energy, *Atomnaya Energiya*.

Progress in Rubber Technology

The current annual report on the "Progress of Rubber Technology" (edited by Dr. T. J. Drakeley, Pp. xi+134. Cambridge: W. Heffer and Sons, Ltd., 1958. 25*s*.), issued by the Institution of the Rubber Industry, gives a brief but reasonably detailed review of developments up to the end of 1957. All aspects of the industry, scientific, technical and economic, are included, and the arrangement in the form of short chapters on specific topics makes for easy reading and quick reference. The subject-matter is not limited to rubbers, but includes materials, such as fibres and plastics, which are used either in association with rubbers or as alternatives to them. Every branch of the industry, including tyres, belting, cables, footwear, cellular rubber, flooring and roads, is covered, and other chapters deal with subjects of more general scientific interest, though these form only a small proportion of the whole. The main value of this publication is that it enables the reader to keep in touch with developments outside his own speciality, and to obtain a quick appreciation of general trends in the industry. Foremost among these is that—in spite of the continued advance of synthetic rubbers and of materials designed to satisfy particular technical requirements—the total demand is expanding at such a rate that the market for natural rubber has remained remarkably stable, and new planting is in progress in various parts of the world. There appears also to be a lively development of scientific interest in new ways of using natural rubber, particularly in conjunction with other polymers, to meet the threat of competition from the synthetics.

New Floristic Studies

The physiography of the vast and interesting region comprising the Canadian Arctic Archipelago has recently been described in a publication issued by the National Museum of Canada, "Illustrated Flora of the Canadian Arctic Archipelago", by A. E. Porsild (National Museum of Canada, Bulletin No. 146: Biological Series No. 50. Pp. iii+209. Ottawa: Queen's Printer, 1957. 2 dollars). The Bulletin also deals with the soils and plant habitats of the region; and numerous illustrations, species distribution maps and keys are provided. In all, some 340 species and major geographical races of flowering plants and pteridophytes are described. The author records that, in this and other floristic studies of the region

which he has undertaken, the Canadian Arctic is defined as including all the land area—some 900,000 sq. miles—which lies north of the treeline, the latter, broadly speaking, following the 10° C. isotherm for the warmest month.

A rather different work, issued by the United States National Museum, Smithsonian Institution, Washington, D.C., as U.S. National Herbarium, 33; 1957, is "The Bromeliaceae of Colombia", by L. B. Smith (pp. vi+311. Washington, D.C.: Government Printing Office, 1957). This family is, of course, very abundantly represented throughout the American tropical and sub-tropical regions. Thus the author of the present monograph notes that, during the past twenty years, the record of known Colombian species has been practically doubled, some 372 species being now known. The Colombian Bromeliaceae fall into three groups: on the criteria of floral morphology, the Andean group is primitive, and the Guiana Highland and Amazonian groups are derivative. The rich representation of two species, *Tillandsia* and *Puya*, have led the author to the tentative conclusion that the family may have originated in Colombia.

Perkin Centenary Trust Awards

THE Perkin Centenary Fellowship has been awarded to Mr. Dennis Balmforth, of Messrs. Courtaulds, Ltd., Coventry, and will be tenable from October 1 in the Department of Colour Chemistry at the University of Leeds. Perkin Centenary Scholarships have been awarded to Mr. Brian Higginbottom, assistant chemist in the laboratories of the Bleachers' Association, Ltd., tenable at the College of Technology, Loughborough, and to Mr. W. K. McCourt, laboratory foreman with Messrs. Courtaulds, Ltd., Carrickfergus, tenable at The Queen's University, Belfast. Arrangements have also been made for a Perkin Exchange Lectureship whereby short visits will be exchanged between Prof. A. J. Birch, of the University of Manchester, and Prof. V. Prelog, of the Eidgenössische Technische Hochschule, Zurich. Prof. Birch will visit Zurich in September 1958, and it is hoped that Prof. Prelog will return the visit in the following year. Each will deliver one or more lectures during the visit, which will last about two or three weeks.

The programme of awards for the year 1959–60 will include one Perkin Centenary Fellowship, valued at not less than £600 a year, which is available to a graduate for higher study, and two Perkin Centenary Scholarships, of £300 a year each, which are intended to give young persons employed in the industries concerned with the manufacture or the application of colouring matters the opportunity of full-time education at a university or technical college. Further nominations are not at present invited for the Perkin Exchange Lectureship. In the place of this award the Trustees will consider making one or more Perkin Centenary Trust Travel Grants to enable teachers concerned in the study of any aspect of the manufacture or application of colouring matters at a university or technical college to make short visits to comparable institutions overseas in order to widen their experience. The Perkin Centenary Trust was established as a memorial to the discovery in 1856 of the first important synthetic dyestuff, mauveine, by William Henry Perkin. The secretary to the Trustees is Dr. J. R. Ruck Keene, to whom inquiries relating to the awards should be addressed, at the Chemical Society, Burlington House, London, W.1.

Announcements

SIR JOHN STOPFORD, lately vice-chancellor of the University of Manchester and emeritus professor of experimental neurology, has been created a baron under the provisions of the Life Peerages Act.

PROF. O. T. JONES, emeritus professor of geology in the University of Cambridge, has been awarded the Liverpool Geological Society Medal in recognition of his varied contribution to and lasting influence on the science of geology over the past half century, and particularly of his illuminating work on the Silurian of North Wales.

THE Council of the British Institution of Radio Engineers has announced the award of a number of premiums for original publications and prizes for outstanding performances in the Institution's graduateship examinations in 1957. The Clerk Maxwell Premium—the premier award for the most outstanding paper published in the Institution's *Journal* during 1957—is to go to Dr. T. B. Tomlinson for his paper, "Principles of the Light Amplifier and Allied Devices", based on work carried out at the research laboratories of the General Electric Company; he is now with Computer Developments, Ltd.

THE work in progress at the National Chemical Laboratory may be seen during the open days to be held on October 21 and 22. Applications from firms for invitations to the sessions should be sent to the director not later than September 20. Firms already on the mailing list for invitations need not re-apply. Further information can be obtained from the National Chemical Laboratory, Teddington, Middlesex.

THE fourth International Conference on Electron Microscopy, organized by the Deutsche Gesellschaft für Elektronenmikroskopie, will be held in Berlin during September 10–17. Further information can be obtained from Prof. E. Ruska, Berlin-Dahlem, Faradayweg 4–6.

THE Indian Central Fuel Research Institute is organizing a symposium on "The Nature of Coal" during February 9–11. Papers, not exceeding 3,000 words in length, with their abstracts, should reach the Director, Central Fuel Research Institute, P.O. Fuel Research Institute, Dhanbad Dist., Bihar, India, not later than October 31.

An informal discussion on "Isotopic Exchange Reactions", sponsored by the Faraday Society, will be held in the School of Chemistry, University of Leeds, on September 25 and 26. The programme will include applications of radioactive and stable isotopes to the study of liquid, gaseous and solid-gaseous systems. Further information can be obtained from Dr. D. R. Stranks, School of Chemistry, The University, Leeds, 2.

A COURSE on the control and instrumentation of reactors is to be held at the Harwell Reactor School during October 6–11. The fee for the course will be 25 guineas exclusive of accommodation. Further information can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell.

ERRATUM. In *Nature* of July 19, p. 158, under "University News: Bristol", for "Dr. J. W. F. McOmie" read "Dr. J. F. W. McOmie".

MECHANICAL PROPERTIES OF WHISKERS AND THIN FILMS

ON March 17–19 some sixty scientists met at the Cavendish Laboratory, Cambridge, and Tube Investments Research Laboratories, Hinxton Hall, for an informal discussion of nineteen papers on "The Mechanical Properties of Whiskers and Thin Films", invited from universities and industrial research laboratories in Great Britain and the United States. The main purpose of the meeting was to review the present state of knowledge on the high mechanical strength observed when one or two dimensions of a test specimen are reduced to a small value. The organizing committee consisted of Dr. F. P. Bowden, Mr. J. E. Gordon and Dr. J. W. Menter.

D. Turnbull (General Electric Co.) opened the proceedings with a survey of mechanisms of whisker growth. Whiskers can be grown either by spontaneous extrusion or by growth into physically or chemically supersaturated media. The former are very strong in bend tests (Galt and Herring) but not in tension tests. Plausible dislocation mechanisms for the observed growth from the root have been advanced by Eshelby, Frank and Seitz.

By contrast, whiskers appearing in physically supersaturated media grow at the tip although they appear to be nucleated at singularities on the substrate. A typical example is mercury, which, after an initial period of growth to a considerable length at a constant thickness of about 100 A., begins to thicken abruptly. Sears suggested that growth occurs by the action of a single axial screw dislocation, and this is supported by the field emission studies of Gomer. Whiskers grown in this way are strong both in bend and tension tests.

Similar mechanical properties are observed in whiskers grown from chemically supersaturated media, which have been extensively studied by Brenner. The growth mechanism is not clearly understood, but Frank has suggested that in some cases it may be controlled by the rate of chemical reduction at the tip or root.

Metal Whiskers

A number of papers then followed on the mechanical properties of metal whiskers. S. S. Brenner (General Electric Co.), in a paper on the plastic deformation of metal whiskers, first summarized the observations of himself and others on the elastic behaviour of whiskers. Elastic strains from 1 to 5 per cent have been reported with a maximum tensile strength of 1,400 kgm./mm.^{2} in an iron whisker about 2μ in diameter (but see Bacon below). Brenner has found that the plastic deformation of copper, silver and iron whiskers occurs by the motion of a Lüders band at a stress sometimes as small as 1 per cent of the yield stress. The local plastic strain in the Lüders band remains constant at values ranging from 0·25 to 0·40 during propagation, depending on the diameter of the whisker. Cross-slip can readily occur at these strains, suggesting that slip may extend along the whisker by a double cross-slip mechanism. Lüders bands are more difficult to observe in iron since extensive local deformation occurs within the band. This local slip is very sensitive to the applied stress, with the result that at high stresses fracture occurs before much of the whisker has slipped. No appreciable part of the elastic strength of whiskers can be recovered by annealing at temperatures up to 600° C. Creep has been observed in iron whiskers and a linear region can usually be observed in which the creep-rate varies roughly exponentially with the applied stress.

N. Cabrera described experiments on the creep of vapour-grown zinc and cadmium whiskers carried out at the University of Virginia with H. H. Hobbs and P. B. Price. An initial non-linear region is observed in the stress – strain curve followed by yield at strains of the order of 1 per cent. If the stress is maintained constant below yield for several hours, creep is observed, the initial creep-rate increasing with the applied stress. A saturation value is finally reached, and once creep has been exhausted at a particular level no more creep is observed at any other level. These results are tentatively interpreted as due to pinned-down dislocations (of the order of 10^8–10^9 cm.$^{-2}$) already present, most of which are pushed out of the whiskers during the creep process, leaving a much more perfect crystal, which then yields at higher stresses (1·5–2 per cent strain). The pinning may be associated with impurities which may be present in concentrations of the order of 10^{-4} impurity atoms per pure atom if the residual resistance observed at liquid-helium temperature is interpreted as due to impurities.

From optical and electron microscope replica studies of copper whiskers, G. A. Geach and P. E. Charsley (Associated Electrical Industries Research Laboratories, Aldermaston) deduced that slip in the Lüders band occurs on only one system, with the implication that the band is not propagated by a double cross-slip mechanism. In whiskers with a $< 211 >$ axis it appears that the slip system in the Lüders band is not that corresponding to the maximum resolved shear stress. The slip distance is observed to depend on size. 5-μ whiskers showed slip steps with up to 0·7μ glide, whereas the amount of glide was only a few hundred angstroms or less for the slip steps on a 20-μ whisker.

The surface characteristics of copper whiskers have been studied by D. Vermilyea (General Electric Co.). D. Turnbull, in presenting this work, suggested that both the physical and chemical behaviour of whiskers free from dislocations except for an axial screw might be unique if their side-walls are perfectly smooth and densely packed. Vermilyea has studied the overpotential required to discharge cupric ions or dissolve copper metal at the surface of copper whiskers. On bulk copper these processes occur at relatively small overpotentials (about 5 mV.) and apparently uniformly over the entire surface. However, overpotentials of about 100 mV. and 20 mV., respectively, are required to discharge cupric ions or dissolve copper metal at the surface of a 3-μ copper whisker, and the electrolytic action occurs only at a few small areas not including the whisker tip. These observations suggest that the surface of these whiskers may indeed be very smooth and with certain reservations may be taken to imply that the density of dislocations in the whisker may be very low.

G. A. Bassett (Tube Investments Research Laboratories, Hinxton) briefly described a new technique for revealing surface steps down to atomic dimensions, which might be useful for studying the surface perfection of whiskers. Evaporated gold layers are found to be nucleated preferentially along step edges on some ionic crystals. These nuclei are detached by means of a carbon film and used as a 'decoration replica' for observations on surface-step structures. It is not known whether similar effects could be obtained on metallic surfaces.

Some qualitative evidence on the dislocation structure in iron whiskers 10–200μ in diameter with axes in $< 100 >$, $< 110 >$ and $< 111 >$ directions was presented by R. V. Coleman (General Motors Corp.). Well-defined etch pits connected with dislocations are observed on {100} faces using 4 per cent picral or 2 per cent nital etchants. Perfectly oriented {100} surfaces do not in general develop etch pits, although random groups of pits are observed on some other surfaces. These are of two types: a 'sharp-bottomed' pit which develops rapidly, and a rounded flattened pit which develops more slowly. Larger numbers of the former develop after plastically deforming the whiskers, the density increasing with deformation and remaining constant with time for a given deformation. After annealing at 850° C. for some hours and etching, polygonized and other arrays of dislocations can be seen.

Non-metallic Whiskers

C. C. Evans, D. M. Marsh and J. E. Gordon (Tube Investments Research Laboratories, Hinxton) described observations on the properties of non-metallic whiskers of hydroquinone, nickel sulphate, sodium chloride, potassium chloride and potassium permanganate. Optical studies show that growth occurs from an initial very thin 'leader' crystal in the micron range, which then thickens by the longitudinal spreading of growth layers. A needle habit can be induced in sodium chloride by the addition of very small quantities of polyvinyl alcohol or sucrose to a saturated aqueous solution. Mechanical tensile tests on crystals of sodium chloride between 1 and 200μ^2 grown in this way have been made with a special testing machine developed by Marsh. Below 2μ^2 the whiskers are fully elastic up to fracture at a strain of about 1 per cent, but with increasing size the elastic limit falls and an increasing region of plastic deformation is observed. In the ductile region, slip bands and local necking are observed, and the largest specimens show some work hardening. The machine is not at present suitable for detecting a sharp yield point.

P. E. Charsley (Associated Electrical Industries Research Laboratories, Aldermaston) has investigated the structure of whiskers of sodium and potassium chlorides by electron microscopy and diffraction. Sodium chloride shows a predominant $< 100 >$ orientation with occasional $< 110 >$, whereas potassium chloride whiskers are invariably $< 110 >$. The most common shape of sodium chloride whisker is bounded by two parallel {100} planes, the other surfaces being irregular, since the edges of growth layers appear to originate in the centre of the {100} faces. These whiskers frequently disintegrate during direct examination under the electron microscope, the larger ones revealing a substructure bounded by $< 100 >$ directions and the smaller (a few tenths of a micron in diameter) showing no regular substructure. This dependence of the substructure on size is correlated with evidence for a layer structure obtained from carbon-replica studies, and it is suggested that layer growth results in lattice imperfections which may be the cause of the decrease in tensile strength with increasing diameter observed by Gyulai.

A. Berghezan (European Research Associates) presented a paper by R. Bacon (National Carbon Research Laboratory, Union Carbide Corp., U.S.A.) describing some interesting observations on graphite whiskers grown by a high-pressure arc process. Whiskers 0·5–5μ in diameter and several millimetres in length show a remarkably high fracture strength of 2,000 kgm./mm.^{2} at an elastic strain of 2 per cent. Most of these whiskers exhibit a ribbon-like form which are often single crystal over their entire length, with the c-axis perpendicular to the axis of the whisker. Some whiskers are cylindrical, but again X-ray examination shows that the c-axis is normal to the axis of the whisker in all azimuths, suggesting a structure consisting of one or more concentric tubes each of which is essentially a large sheet, many atomic layers thick, rolled up into a tight spiral scroll. Growth is thought to occur by addition of carbon to the spiral edge of the rolled-up sheet so that the whisker elongates rapidly (10 in./hr.). The elastic modulus of these whiskers is about 100 times that of bulk polycrystalline graphite.

Some aspects of the theory of dislocations in whiskers were considered by J. D. Eshelby (Department of Metallurgy, Birmingham) and J. P. Hirth (Carnegie Institute of Technology). The former described a method for calculating the twist which an axial screw dislocation produces in a whisker of arbitrary cross-section, and briefly discussed the stability of the dislocation. Hirth considered the possibility of thermally activated slip of dislocations out of metal whiskers, as a possible mechanism for the cessation of whisker growth. Whiskers with radii less than a critical value will not retain a single axial dislocation. Above the critical radius the dislocation will slip out only if it has an edge component of about 0·3 times the Burgers vector with respect to the axis of the whisker. The effects on whisker morphology predicted by this mechanism were shown to be consistent with observation.

Most of the evidence on crystalline whiskers seemed to indicate a fairly definite dependence on size of mechanical properties. Earlier work on non-crystalline glass fibres followed the same trend, but more recently it has been shown that if care is taken to avoid surface damage, strength is virtually independent of fibre size. The problem of size, strength and structure in glass was discussed in a paper by M. E. M. L. Parratt, D. M. Marsh and J. E. Gordon (Tube Investments Research Laboratories, Hinxton). On the assumption that failure is associated with surface defects, an improved sodium decorating technique has been used to study surface crack patterns and definite correlations have been made between their extent and the mechanical strength. These crack patterns present on the surface of all fire-polished glass seem to control the mechanical strength up to at least 3 per cent strain. The origin of these cracks is not clear. Electron microscope studies on thin films of glass showed that devitrification could lead to cracks, but an alternative source was abrasion, the susceptibility to which may be associated with the state of stress of the surface.

The importance of the surface condition was emphasized by D. G. Holloway (University College of

North Staffordshire), who has found that the bending strength of 60–120-μ 'Pyrex' fibres is larger by a factor of 5–6 when drawn and tested under high vacuum compared with those drawn and tested in air or those drawn in vacuum and tested in air. The drop in strength was attributed to atmospheric attack on the surface.

Thin Films

D. W. Pashley (Tube Investments Research Laboratories, Hinxton) has studied the tensile deformation of single-crystal films of gold in (111) orientation, 500–2000 A. in thickness, inside the electron microscope. No movement of the grown-in dislocations (10^{10}–10^{11} cm.$^{-2}$) was observed as the strain was increased to about 1 per cent, and this strain was confirmed as elastic by measurements on electron diffraction patterns from the strained film and by means of stress-strain measurements carried out externally by D. Marsh.

At an elastic strain of about 1 per cent the film was observed to fracture by the propagation of a highly localized region of plastic deformation along the film corresponding to slip on (11$\bar{1}$), (1$\bar{1}$1) and ($\bar{1}$11) planes. This led to complete fracture of the thinner films, but with thicker films short regions where fracture occurred were joined by regions of less localized plastic deformation.

T. Evans (Tube Investments Research Laboratories, Hinxton) described experiments in which similar single-crystal films of gold, gold/palladium, rhodium and platinum oriented on substrates consisting of single crystals of silver were deformed as a result of tensile stress applied to the substrate. In this situation the film may become deformed plastically with the substrate up to large deformations, provided dislocations from the substrate are able to pass into and through the film. The important determining parameters are the relative lattice misfit between film and substrate and the relative elastic moduli. Examination by transmission electron microscopy of films stripped after deformation showed that gold and gold/palladium accommodated the strain of the substrate by slip, whereas platinum and particularly rhodium films had many cracks following the traces of slip planes in the substrate, implying that the film had cracked locally due to the stress concentration arising from piled-up groups of dislocations on the substrate slip planes immediately below the film.

P. B. Hirsch and M. J. Whelan (Cavendish Laboratory, Cambridge) considered the factors determining the strength of thin metal foils with free surfaces, inferred from their direct observations in the electron microscope. Moving dislocations leave behind traces at the top and bottom surfaces, which are thought to be surface dislocations held up at the interface between the metal and an oxide or other type of surface film.

For a thick oxide film the stresses required to move dislocations approach the critical Frank–Read stress of the dislocation line in the metal film. Estimates of this stress from curvature of the line suggest that some dislocations move under stresses of about $G/1{,}000$ in foils about 1000 A. thick. Although in favourable circumstances it is expected that a Frank–Read source might operate, no direct observation of such a source has been made.

However, dislocations have been observed to nucleate near the edge of a thin foil. The dislocations appear to be half loops which have run in from the edge. Following a suggestion by Cottrell, nucleation of dislocations in a wedge crystal has been considered theoretically. It is found that, for a dislocation with Burgers vector in the surface of a thin foil with a wedge angle of 0·1 radian, the activation energy for nucleation is about 1 eV. at stresses of the order of $G/150$. This theory may possibly account for the observed nucleation in the majority of cases.

B. A. Bilby (Department of Metallurgy, Sheffield) also considered theoretically the nucleation of slip in thin plates, using solutions of elastic equations given by Leibfried and Dietze and by Eshelby and Stroh. For a long straight screw dislocation parallel to the plane of the plate a significant reduction in the activation energy occurs only at very high stresses or for very thin plates. A calculation was also made for the introduction of a pair of screw-dislocations lying normal to the plate, with results confirming in order of magnitude those of Hirsch and Whelan for the thin wedge. The energy of steps forming and disappearing on the surfaces as the dislocations are introduced plays an important part, but more detailed models are required to assess their effect quantitatively.

J. Nutting and D. G. Brandon (Department of Metallurgy, Cambridge) have tested iron foils, 99·97 per cent pure, in tensile deformation, with different thickness and grain size. The yield stress and extent of yield decreased and the rate of work hardening increased with decreasing foil thickness (down to less than 30μ). In coarse-grained foils the yield phenomenon was less affected than in the fine-grained. Factors affecting the behaviour of the foils include stress concentration due to local variation in thickness, decrease of constraints on individual grains, triaxial stress distributions resulting from surface rumpling during deformation and possible changes in the dislocation mechanism for deformation. No evidence for the last had been found by transmission electron microscope studies on thinned foils, although more deformation and kink bands and relatively few slip lines are seen on the surface of the thinner foils.

R. B. Nicholson (Department of Metallurgy, Cambridge) showed that the coherency strains associated with Guinier–Preston zones in aluminium/4 per cent copper alloys could be made directly visible in thin films of the alloy studied in the electron microscope and discussed their effect on the age-hardening characteristics of this alloy. G. Thomas (Department of Metallurgy, Cambridge) has studied precipitation phenomena and dislocation structures in thin foils of aluminium/magnesium/zinc alloys in the electron microscope. When previously aged beyond maximum hardness it is possible to cause movement of dislocations in the foils by heating in the electron beam. The chief sources of dislocations appear to be the grain boundaries. The stresses obtained by heating appear to be insufficient to move dislocations through precipitates.

As was intended, the papers given were essentially accounts of work in progress, and it is therefore not easy to give a considered view of the field as a whole. Explanations of the high strength of whiskers start from two conflicting assumptions about their microstructure. Some whiskers are undoubtedly highly perfect and it is reasonable to expect these to show a long elastic range. Whether surface perfection is essential for strength in addition to interior perfection depends on the view taken of the possibility of nucleation of dislocations or cracks from surface

irregularities. The alternative view is that whiskers may well be imperfect, but high strength may still be observed because of the pinning of dislocations and inhibition of sources due to the small dimensions of the specimen. Both the latter strengthening mechanisms have been shown to be plausible for thin films from direct observation in the electron microscope, and it would be valuable to have more direct information of a similar nature about whiskers. Equally it would be valuable to have much more information about the relation between strength and thickness for thin films.

It is important to know more about changes in mechanisms and modes of deformation with thickness and also whether a small thickness alone is adequate to achieve high strength. The structure of the film arising from the particular method of preparation may also turn out to be important.

J. E. Gordon
J. W. Menter

CHEMISTRY OF PLANT PRODUCTS

THE Royal Australian Chemical Institute's Western Australian Branch, in co-operation with the University of Western Australia, held a symposium on "Plant Products" at the Chemistry Department of the University on March 20 and 21. The first day was devoted to general and technological papers and the second mainly to structural chemical investigations. About 45 members and guests attended the two sessions.

After introductory remarks by Dr. D. E. White, president of the Branch, who welcomed the visitors, Dr. J. R. Price (Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne) outlined the development of phytochemistry in Australia, from the pioneers, like the Surgeon of the First Fleet, to its present flourishing state. Work in this field is carried on in most of the Universities and also by the Commonwealth Scientific and Industrial Research Organization. After discussing briefly the role of these institutions, Dr. Price summarized the scope, organization, objectives and potentialities of current work in the Division of Industrial Chemistry. Mr. R. H. Pearce (Kwinana Chemical Co., Kalamunda) described the application of solvent extraction and chromatography to the separation of fractions from *Xanthorrhoea* resins. Variations with species and age of the resin were discussed and some components were found to be unstable in light and air. The techniques used appear much more promising than those previously used in attempts to isolate compounds from this resin.

An account of the use of growth regulators in viticulture was given by Mr. L. T. Jones (Department of Agriculture, Perth), who described the effect of hormone spraying in place of the obsolete and harmful practice of cincturing vines. Local research work illustrated the superiority of such hormones as PCPA, 2,4-dichloro- and 2,4,5-trichloro-phenoxyacetic acids and gibberellic acid, resulting in increased production, improved fruiting, prevention of preharvest fruit drop and the killing of unwanted vines. Reference was made to the disadvantages of hormone spraying, for example, damage to bunches and vines, but these were due to incorrect application of the spray. Mr. Jones pointed out that gibberellic acid (not strictly a hormone), had been used experimentally only recently, and the results obtained suggest a promising future for the use of this material in viticulture. A striking contrast between the sizes of bunches on treated and untreated vines was shown in colour slides.

Mr. W. E. Hillis (Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne) discussed chemical aspects of the sapwood-heartwood transformation, referring particularly to the increased polyphenolic content of the heartwoods of Australian timber trees. These components, which contribute to durability, may be derived from the cambium, the leaves or the starch in the sapwood, and evidence indicates that an appreciable portion arises from the latter. The significance of the shikimic acid content of *Eucalyptus sieberiana* leaves of different sizes, before and after shading, was discussed.

Dr. H. Jakobs (Leederville, W.A.) described how chemical research had made possible much of the agricultural development in the Dutch East Indies. He exemplified this in detail by reference to the tea industry, which is now of major importance in Indonesia.

Dr. D. E. White discussed a study made with D. K. Dougall on the 'primary' tars, obtained by distillation of jarrah and karri sawdust *in vacuo*. Among the compounds isolated catechol, 2 : 6-dimethoxyphenol, 1 : 2 : 3-trihydroxybenzene, 5-methylfurfural and D-glucosan (1 : 5)β(1 : 6) were identified. Decomposition of the latter was responsible for the low decomposition temperature of the tar.

The second day's proceedings opened with a paper on the chemistry of stock poison-plants by Dr. C. C. J. Culvenor (Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne) read by Dr. J. R. Price. The liver-damaging pyrollizidine alkaloids and their N-oxides isolated from Compositae, Leguminosae and Boraginaceae were described with special reference to the recognition of monocrotaline from *Crotalaria retusa* as the cause of Kimberley horse disease. Recent work on other *Crotalaria* spp. was also discussed.

Dr. P. R. Jefferies (Chemistry Department, University of Western Australia) outlined the principles of gas chromatography and showed how it could be used for the quantitative analysis of simple mixtures. Complex mixtures as found in essential oils can be studied qualitatively, first on the whole oil, and then on distillation fractions. In this way the isolation of pure compounds is greatly facilitated and the presence of high-boiling components can be easily detected.

The constitution of the sesquiterpene alcohol globulol was discussed by Mr. G. J. H. Melrose in a joint paper with P. R. Jefferies and D. E. White. He described new sources of this alcohol in Western Australian Myrtaceae, and the synthesis of an epimer by the reaction of methyl magnesium iodide with apoaromadendrone. This alcohol also affords aromadendrene on pyrolysis of its 3 : 5-dinitro-

benzoate. Hence the junction of the 5 and 7 membered rings in aromadendrene must be the more stable (*cis*) type. Other features of the stereochemistry of globulol and *epi*-globulol were also discussed and evidence for the attachment of the *cyclo*propane ring to C_6 and C_7 was outlined.

The chemistry of *Lunasia* alkaloids was discussed by Dr. J. R. Price, who compared the American work on *L. amara* with that done in the Commonwealth Scientific and Industrial Research Organization on *L. quercifolia*. In addition to the tertiary bases, lunacrine and lunacridine, water-soluble bases were present, the major component of which analysed for $C_{17}H_{22}O_3N^+$. A possible structure for this compound, which forms lunacridine when treated with alkali, was presented.

Mr. J. O. Knight presented the final paper in collaboration with A. R. H. Cole, D. C. Shaw and D. E. White, on triterpenoid constitutents of the Myrtaceae. After discussing the common occurrence of betulic acid in members of this family he dealt with the structure of melaleucic acid. The structure originally assigned (3β-hydroxylup-20(29)–en–25 : 28-dioic acid; *Chem. and Indust.*, 926; 1956) cannot be correct since the lactone which was assumed to involve the 3-hydroxyl and the 25-carboxyl affords a tertiary hydroxyl group on reduction with lithium aluminium hydride. The second carboxyl group must be on C_{26} or C_{27} and its lactonization involves re-arrangement. Means for distinguishing between these possibilities were discussed.

D. E. White

THE INSTITUTE OF BIOLOGY

ANNUAL CONVERSAZIONE

THE annual conversazione of the London Branch of the Institute of Biology was held at University College on the evening of July 3. Prof. G. P. Wells and Dr. K. Mellanby (chairman of the London Branch) received members and their guests in the North Cloisters of the College. A large number of exhibits was on display in the Zoology Department, by courtesy of Prof. Wells.

The range of activities of this year's guest Society, the Botanical Society of the British Isles, was well shown by its exhibit. Of particular interest was its progress in the scheme to produce a map of the distribution of British plants. The mass of data for this scheme has been reduced to a minimum of space by the use of a punched-card system, and it is hoped that an atlas of British plants will be produced in 1960. A related project has been undertaken by the British Naturalists' Association, whose exhibit illustrated their work on a phenological survey which will map the changes in the flora and fauna which occur during the year and also the fluctuations of longer period.

Hospital and Laboratory Supplies, Ltd., provided this year's trade-stand, which gave a sample of the comprehensive range of apparatus and materials which this firm can supply. Specimen publications of the Universities Federation for Animal Welfare and of the Institute of Biology were on display, and the Department of Extra-Mural Studies of the University of London had produced an exhibit to illustrate the work of the Department in the field of biology.

Aspects of the Falklands Islands Dependencies Survey biological research were shown, including the method of ageing individual seals by the annual increments of dentine or cementum in the teeth, and also illustrating work on the reproductive cycle of the southern elephant seal. The Ministry of Agriculture, Fisheries and Food provided a stand showing advances in food research and development, particularly in food dehydration, and its Infestation Control Division was represented by Mr. G. A. Brett's exhibit of a common tropical cockroach, *Pycnoscelus surinamensis*, which is occasionally imported into Britain.

In addition to the exhibits of organizations, a large number of exhibits had been provided by members and guests. Studies on pest control provided the basis of several of these. An example of a serious infestation of a house by the ant *Lasius brunneus* was found in 1957 (A. A. Green), and there is some evidence of an increased tendency for this ant to invade houses. Population studies of locusts (R. F. Chapman) have made it necessary to be able to separate the egg-pods of locusts from those of other species; various characteristics of the pod can be used. The way in which infestation in a bulk of grain causes heating (D. H. Burges) introduced a model showing the rate of development of colonies of the flat grain beetle (L. P. Lefkovitch), colonies of up to 550,000 individuals being produced in 4 months.

A more gradual example of population increase was shown by the frog *Rana ridibunda* (J. I. Menzies); 12 specimens were introduced into England in 1935, and their descendents have spread at the expense of the British *Rana temporaria* and now cover 120 square miles of S.E. England. New anatomical work on the classification of the lugworm genus *Arenicola*, which can be divided into two groups, was shown by Prof. G. P. Wells, with a map of the zoogeography of this genus. Two very different types of colour change in the Orthoptera were shown (K. H. L. Key), some acridids showing a physiological change from black to blue as a direct reaction to increasing temperature, while some phasmatids show centromorphic colour changes related to population density.

Some exhibits were concerned with genetical studies. Studies on finger-print patterns (S. B. Holt) have shown that the total ridge-count is determined by additive genes with an independent effect but without dominance. In the fungus *Aspergillus nidulans* (M. Mahoney and D. Wilkie) some spores give rise only to asexual colonies; this appears to be due to the loss of a self-replicating cytoplasmic unit. The rare genetically determined biochemical defect in man known as gargoylism (U. Mittwoch) can be detected by the presence of abnormal inclusions in the lymphocytes.

An exhibit of the different degrees of specificity of both the bacteria and the leguminous plant in their symbiotic relationship (P. S. Nutman) showed also the way in which different mutant strains make it possible to study how the relationship develops. New methods of studying the cellular constituents of yeast (A. A. Eddy) have resulted from the discovery that protoplasts can be prepared by treating yeast cells with certain digestive enzymes of the snail *Helix*.

Exhibits concerned with research techniques included the compact lightweight McArthur microscope, designed for field-work; new uses for cellulose acetate in the culture of anaerobic bacteria and in electrophoresis (W. H. Pierce); and the confining of insects to treated plants under controlled conditions, for use in insecticide screening (D. T. Saggers).

There were many other exhibits, of no less interest and attractiveness than those mentioned above, and the exhibits as a whole provided starting-points for the informal discussion and conversation between those present which are, after all, the prime purpose of a conversazione.

C. B. Cox

MARIAN SMOLUCHOWSKI

MARIAN SMOLUCHOWSKI, the great Polish theoretical physicist, died during the First World War on September 5, 1917, in Cracow, and a description of his life and work was published by A. Teske three years ago ("Marian Smoluchowski: His Life and Work". Polish State Scientific Publishing House, Cracow, 1955). However, for those not familiar with the Polish language, the brief account of Smoluchowski's career and of his contributions to the theory of probabilities in physics given in the article contributed by S. Ulam to the October number of *The American Journal of Physics* (**25**, 475; 1957) will be very welcome.

Smoluchowski was born in Vienna in 1872. His father was a Cracow lawyer who later became secretary of the Chancellery at the Court of the Emperor Francis Joseph. His mother, too, was well educated, and Smoluchowski was brought up in highly intellectual surroundings. He early showed an interest in science and he studied mathematics and physics at the University of Vienna, attending the lectures given by Boltzmann, Mach and others. He published his first scientific paper in his second year at the University, finally graduating with the highest honours. After a year in Paris working with Lipmann, he studied for a year in Glasgow under Kelvin and then spent a few months in the laboratory of Prof. Warburg in Charlottenberg, finally returning to Vienna to become a lecturer in the University of that city. In 1899 he became a lecturer in Lwow, and the next year, at twenty-eight, he was promoted to a chair of theoretical physics, thus becoming the youngest professor in Austria. In 1913 he was offered, and accepted, the chair of experimental physics at Cracow, but was evacuated to Vienna in the early part of the First World War. The University of Cracow made him rector when he was invited again in 1917 to the chair of theoretical physics in Vienna, but Smoluchowski died suddenly at the age of forty-five before he could deliver his inaugural address entitled "On the Uniformity of Laws of Nature".

Probability theory played an important part in physics during the forty years following Smoluchowski's premature death, and Smoluchowski can claim to have started and anticipated much of the subsequent development. He, together with and independently of Einstein, elaborated and carried forward the ideas of Maxwell and Boltzmann. One of Smoluchowski's mathematical achievements was the clarification of the ergodic hypothesis of Boltzmann and of its place and meaning in statistical mechanics. He realized the difference between the logical structure of the Maxwell and Boltzmann theories and the statistical mechanics of Gibbs. Though primarily a theoretical physicist, Smoluchowski was also very adept in the design and construction of instruments and an extremely good glass-blower. While at Lwow he carried out a brilliant series of experiments confirming Lord Rayleigh's theory that the blue of the sky was caused by the scattering of light. He paid several visits to Great Britain both for mountaineering in Scotland (one of his great passions), and also on academic business. He was an active member of many scientific societies, in particular the Polish Physical Society, of which he became the first president, and he contributed many papers to scientific periodicals, some collections of which have been published since his death.

MENTAL HEALTH RESEARCH FUND

OFFICIAL figures show that in 1956 there were in England and Wales more than 204,000 hospital beds occupied by patients suffering from mental illness or mental deficiency. This figure can be compared with the 219,000 occupied beds for all other diseases put together. In addition, there were more than 81,000 mental defectives under some sort of supervision provided by the local authority and an unknown number of persons suffering from neuroses which impair their efficiency and happiness. This problem is increasing. In 1949, it led to the formation of the Mental Health Research Fund by a small group of scientists, doctors, and laymen who shared the belief that mental health and mental illness were not receiving that share of attention in research which their importance demands.

The Fund was registered in 1952 and heads of leading research institutions in Great Britain were invited to say in what ways they would wish to use any money that might be available for work in promoting mental health.

A conference at Oxford was then convened to which were invited a wide cross-section of scientists, ranging from anatomists to sociologists, as well as a number of practising psychiatrists and professors of psychiatry. Its terms of reference were to answer the following questions: What are the ignorances which to-day principally hamper understanding of the nature, prevention and cure of mental illness? What advances in research are most likely to remove these and so help to reduce the population of mental hospitals and institutions for delinquents?

The Fund has now defined its main purpose and responsibilities as follows: The establishment of research fellowships in the several fields of mental

science; encouraging co-operation between workers in different fields of mental science by arranging conferences; supporting specific lines of investigation by providing technical assistance, expenses or equipment for research workers; and arranging for the exchange of information with workers in other countries by financing attendance at regional and international meetings.

To further these objectives, the Fund proceeded to collect money and make grants on an increasing scale. It was fortunate in receiving grants from the Ford Foundation, the Leverhulme Trust, the Peel Trust and the National Society for Mentally Handicapped Children, as well as valuable support from the general public.

The Fund has now well-established procedures for inviting and assessing applications for support. Every research centre in Great Britain has been informed of the Fund's interest, of the kinds of help it is able to offer, and receives annually its invitation to prospective applicants.

During 1957 the Fund planned and issued invitations to the international conference recently held in Oxford. The theme of this conference was the concept of stress; its main object was to elucidate the variations of this concept as used in psychiatry and to relate them to each other and to the somewhat different concepts of stress which are used in physiology. Information about the Fund may be obtained from 39 Queen Anne Street, London, W.1.

GLACIOLOGICAL OBSERVATIONS ON RUWENZORI

THE Department of Geography of Makerere College in the University College of East Africa has recently distributed a duplicated report* of eighteen quarto pages on the reconnaissance expedition to Mt. Ruwenzori conducted by four members of the College staff during December 28, 1957–January 12, 1958, under the leadership of Mr. F. P. Henderson, lecturer in geology. The object of the expedition was glaciological: it was hoped to make observations on some of the thirty odd glaciers of the mountain which would provide information as to their state during the International Geophysical Year. Oriented photographs were taken from marked sites of the highest peaks, Stanley Ice Plateau, and four or five of the principal glaciers; comparison with photographs taken by earlier expeditions reveals a general and considerable wastage of the Ruwenzori glaciers. In addition, a hut was erected above the snow line, a survey base was marked and measured, and from it the positions of a series of markers on the Elena glacier determined. Only one of several markers placed on this glacier by previous expeditions was discovered, and even this was useless since its original position could not be fixed.

It is concluded by the leader that relatively small expeditions of this type at fairly frequent intervals offer a more promising mode of attack on the problems of this mountain than do more elaborate expeditions widely spaced in time. Accordingly, it was planned to follow up the reconnaissance with a further expedition six months later. On June 23, *The Times* reported that this expedition, again under the leadership of Mr. Henderson, began the ascent of the mountain on June 10, but operations had to be given up on June 18 owing to the illness and death from pneumonia of Mr. William Dickins, lecturer in geography in the Department of Education. During the reconnaissance, one member of the expedition, Dr. Whittow, contracted bronchial trouble and retired from the mountain, and, indeed, high-altitude pneumonia is a well-known phenomenon on Ruwenzori.

The courage of the young men of these two expeditions in planning fairly regularly repeated observations on a mountain with such a notorious weather record and under conditions that allow of little time for acclimatization is wholly to be admired; but the tragic outcome of the second expedition leads one to express the hope that in future their plans may receive, in Government and university circles in Uganda, financial support sufficient to allow them to operate with larger margins and to permit the inclusion of a medically qualified member in the team.

David L. Linton

* Report of the Makerere College Ruwenzori Reconnaissance, December 1957 to January 1958. Pp. 18. (Kampala: Geography Department, Makerere College, 1958.)

ROLE OF TURBULENT SCATTERING IN LONG-DISTANCE RADIO PROPAGATION AT METRE WAVE-LENGTHS

By F. A. KITCHEN and Dr. M. A. JOHNSON
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SOME controversy has recently arisen[1] in regard to the practical confirmation of the theoretical prediction[2,3] that a permanent mechanism of long-distance propagation of short radio waves will arise from scattering by randomly distributed irregularities of refractive index associated with atmospheric turbulence. Some recent experimental results which appear to confirm its presence at metre wave-lengths are now presented.

Following the series of metre-wave experiments recently described[4], further work was carried out by the Admiralty Signal and Radar Establishment in November and December 1957, in the English Channel area, using a ship-borne transmitter against a shore-based receiver near Portsmouth, on a frequency of 203·5 Mc./s. The transmitter and receiver were those used in previous experiments[4], but with the addition of a high-speed continuous recorder of received field-

strength, of time constant 0·1 sec., and an automatic signal-level distribution analyser for the determination of the instantaneous amplitude distribution. The latter was operated for 3-min. sampling periods, comprising 1,000 individual signal samplings, for each of which the resolving time was 20 m.sec. The height above sea-level of the receiving aerial was 120 m. and that of the transmitting aerial was 12 m. The latter produced a radiation pattern in the vertical plane in which the lowest lobe was elevated at an angle of about $1\frac{3}{4}°$ above the horizon. This has been allowed for in applying the theoretical treatments of the possible propagation mechanisms to the observed results. It is believed that this has no influence on the interpretation of the propagation mechanisms involved.

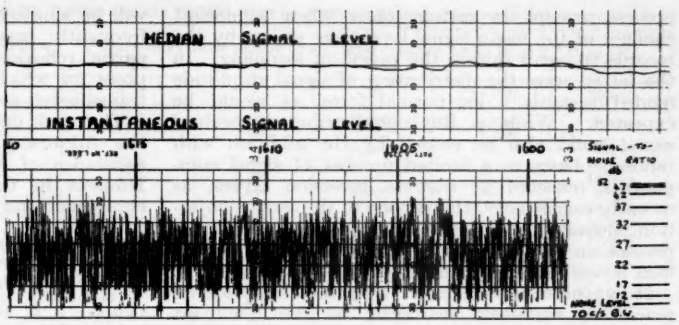

Fig. 1. Long-range propagation measurements, 203·5 Mc./s., December 11, 1957. English Channel area

Field-strength recordings were made for a number of outward runs by the ship, on a true bearing of 245°, for ranges of up to 350 nautical miles. Both the median level and the fading characteristics of the signal were carefully analysed. Further, the instantaneous signal amplitude distributions were obtained from the analyser data by plotting on normal and Rayleigh probability paper. A careful examination was made of the surface and upper-air meteorological data published by the Meteorological Office for the period concerned. Although no upper-air data were available for places nearer the transmission path than Camborne, Cornwall, on each of the particular runs to be discussed the meteorological situation was the same over a wide area surrounding the transmission path, as evidenced by the charts for the various fixed levels and the close similarity of upper-air conditions at Camborne and more distant stations such as Crawley and Valentia.

On each of the three runs made by the ship during the period November 25–29, involving ranges between 110 and 250 nautical miles, the characteristics of the received signal field were very similar, and of a type familiar from previous experiments (ref. 4, type 'B'). The fading was of the 'roller' type: broad flat maxima separated by deep sharp minima, over a range of 20–30 db., and of period 1–5 min. On each run the transmission path lay in the central regions of a persistent anticyclone. It is well known that subsidence normally occurs at upper levels in these conditions, and across the boundary between the subsiding air and the surface layer there will occur both a rapid increase of temperature and a rapid decrease of water-vapour content, giving a thin layer of sharp decrease of radio refractive index. The upper-air meteorological (radio-sonde) data confirm the existence of such a layer, at a level of about 1,500 m., at all the above-mentioned stations. It is difficult to make quantitative estimates of the partial reflexion of the incident wave which will occur at this layer, since the available upper-air data are too coarse to permit its thickness, or the form of the variation of refractive index within it, to be determined. The reflexion coefficient of the layer decreases rapidly if its thickness $t > t_0 = \lambda/4\pi\alpha$, where λ is the radio wave-length and α the angle of incidence on the layer. For the experiment under consideration, the maximum value of this critical thickness t_0 is 15 m. at 110 nautical miles total range, decreasing to 6 m. at 250 miles. However, there is some evidence that inversion layers caused by subsidence in anticyclones can have thicknesses not greatly exceeding these values; this seems reasonable, since under conditions of anticyclonic subsidence wind speeds are small and the temperature lapse-rate is stable, so that turbulence is weak. Although the form of the variation of refractive index within the layer is still unknown, it seems reasonable to assume that the radio transmission was primarily due to partial reflexion from the layer, and this hypothesis is consistent with the fading characteristics of the received signal. The observed median signal-levels were considerably higher (usually 30–50 db. below free space at the shorter ranges, and 50–70 db. below at the longer ranges) than those which scattering theory[3] predicts, particularly since, as already mentioned, the intensity of turbulence was likely to be less than usual. The meteorological data confirm directly that the upper winds were very light and the temperature lapse-rate small. Thus, a contribution from scattering to the received signal would be negligible, by comparison.

However, the results of the run made on December 11–12 were completely different. Throughout this run, which covered the range interval from 140 to 260 nautical miles, the received signal suffered extremely rapid fading (Fig. 1), at a rate of about 30 cycles per minute. The observed median signal-level showed a slow and fairly uniform attenuation with range; its levels at 150 and 250 nautical miles range were respectively about 75 and 90 db. below the free-space values, corresponding to a mean rate of attenuation of 0·15 db./mile. These values are all in good agreement with predictions made from turbulent scattering theory[3]. During the whole of the run the transmission path lay within an air stream which is shown by the upper-air data, and by the development of convective type cloud and showers, to have been unstable, up to at least 7 km. height. Strong turbulence would thus be expected over the most important part of the scattering volume. Further, this instability and turbulence would be likely to preclude the formation of stratified layers, especially of thickness small enough to give appreciable partial reflexion. No inversion layers were apparent in the refractive-index–height distributions constructed from the upper-air data.

Further, the rate of fading observed is in excellent agreement with predictions from scattering theory[5], but would be difficult to explain on the hypothesis of a reflexion mechanism. The instantaneous signal amplitude distributions were close to the Rayleigh form which would be expected for a random scattering

process, except in certain cases when significant changes of the mean signal-level were shown by the records to occur during the period of sampling. In the latter cases the distribution of signal amplitude tended towards a log normal form, as would be expected. While a Rayleigh-distributed received signal could also be caused by the addition with random phases of a limited number of signal components reflected at discrete inversion layers, as recently suggested[6,7], this is open to the serious objection, already mentioned, that the strong turbulence present on this occasion made the existence of such thin layers extremely unlikely.

It is therefore suggested that all the evidence points to turbulent scattering as the dominant propagation mechanism on this occasion. Further, since, on both theoretical and experimental grounds[3], it seems that turbulence to some degree must almost always be present at all levels in the troposphere, it may be concluded that the scattering mechanism will be similarly permanent. It will, of course, be frequently masked by the stronger mechanism of partial reflexion, but can only be neglected for purposes for which only occasions of unusually strong transmission are of interest.

The work described is published by permission of the Admiralty. We desire to acknowledge the assistance of Messrs. I. J. Richmond and W. L. Hibbens in the preparation of the experimental equipment and in the conduct of the observations.

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PROTECTION OF LIVING CELLS AGAINST ACID BY CERTAIN NON-IONIC AND AMPHOTERIC SOAPS

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IT is reported that the interior of phagocytic cells is, or can become, acidic[1], but it is undecided how far this property might contribute to the destruction of certain bacteria ingested by them[2]. Tubercle bacilli can survive and multiply within these cells, or be inhibited in growth or destroyed, according to circumstances[3]; this bacterial species is well known to be relatively resistant to acid, though the resistance is far from absolute[4]. Certain non-ionic soaps, namely, certain polyoxyethylene ethers, which are without apparent effect on the multiplication of tubercle bacilli *in vitro*, exercise a strong effect *in vivo*—some suppressing and others enhancing experimental tuberculous infection; their site of action is considered to be within the monocytic phagocytes[5–8]. It was therefore of some interest to examine the effect of these agents on the resistance of tubercle bacilli to acid.

Preliminary experiments provided no simple explanation of the action of the agents on tuberculosis, but they revealed a general phenomenon which forms the subject of this article. The experiments have been extended to include exposure of other bacteria besides *Mycobacterium tuberculosis*, as well as of human red blood-cells, to acid in the presence and absence of various non-ionic soaps and other compounds.

Suspensions of micro-organisms were obtained from cultures on solid nutrient medium. The reaction mixtures contained usually 1 *M* or 0·1 *M* hydrochloric acid (to give a final measured *p*H of 0·6 or 1·2, respectively), or 0·1 *M* citrate buffer (to give *p*H 3·5, 5·0 or 7·0), or no buffer (*p*H 7·0); a non-ionic soap 1·25 per cent w/v; albumin 0·025 per cent; micro-organisms 10^6–10^7/ml.; total volume 4·0 ml. The mixtures were incubated in 25 mm. diameter test-tubes at 37° C. for 3½ hr., with intermittent shaking by hand. After neutralization, viable counts were made on nutrient medium from 0·02 ml. drops of suitable dilutions. Human red blood-cells were suspended in 0·13 *M* sodium chloride containing 0·03 *M* acetate buffer at a final *p*H of 3·5 and upwards; and the extent of hæmolysis during 3 min., in the presence or absence of the test substance, was noted.

Table 1 shows tests of the effect of non-ionic soaps and other substances, including the phospholipid lecithin, against the lethal action of acid solutions on *N. tuberculosis*. Somewhat surprisingly, all the non-ionic soaps tested (including saponin and polypropylene glycol) are able to protect the bacilli against acid. Even more interesting is the observation that the amphoteric soap lecithin acts similarly. Soaps able to suppress experimental tuberculosis ('Triton *WR*1339') are just as effective as those that are protuberculous (*HOC*-60). Other molecules of similar size but possessing no soap-like activity, for example, polyethylene glycol, sucrose and suramin, were unable to protect.

The protective action of the soaps was next tested with another species of *Mycobacterium*, with three other species of bacteria normally less resistant to acid, and with human red cells. Table 2 shows that the killing of the various bacterial species by acid is also impeded by a typical member of the soaps, though at a different *p*H from that with *M. tuberculosis*. The hæmolysis of red cells by acid is considerably delayed in their presence.

Very approximately the effect of the soaps is to increase the concentration of hydrogen ions required for rapid destruction one hundredfold, that is, a shift of 2 *p*H units. The soaps do not appear to confer complete protection against the bactericidal and hæmolytic effects of acid: their action is to reduce considerably the rate at which damage occurs. In this connexion the bacteriostatic action of weakly acid solutions (*p*H 5–6) upon tubercle bacilli is not prevented by the soaps. Under otherwise identical

Table 1. LETHAL ACTION OF ACID ON TUBERCLE BACILLI (STRAIN *H37Rv*) WITH OR WITHOUT VARIOUS NON-IONIC SOAPS, ETC.

Substance	Concentration (per cent w/v)	Survivors (viable units/0·02 ml.) after exposure for 3½ hr. at 37° C. at *p*H: 0·6	1·2	3·5	5·0	7·0
Control without soap	—	< 1	1	30	10,000	10,000
'Triton *WR*1339'*	1·25	< 1	6,000	8,000	10,000	10,000
HOC-60 (*GN*/102)*	1·25	< 1	7,000	—	7,000	—
HOC-75 (*GN*/104)*	1·25	—	—	8,000	—	—
Saponin	1·25	< 1	3,000	—	—	10,000
Polypropylene glycol M.W.425	1·25	< 1	1,000	—	—	10,000
Lecithin (egg)	1·0	—	6,000	8,000	—	8,000
Polyethylene glycol M.W.600	1·25	—	< 1	—	—	10,000
Suramin	1–10	—	< 1	—	—	10,000
Sucrose	1–50	—	< 1	—	—	10,000
Glycerol	5–50	—	< 1	—	—	2,000
		Survivors after exposure for 24 hr.				
Control	—	—	< 1	< 1	—	10,000
'*WR*1339'	1·25	—	850	7,000	—	10,000

* 'Triton *WR*1339' is a polyethylene glycol ether of a *p-tert*-octylphenol-formaldehyde linear polymer; *HOC*-60 and *HOC*-75 are polyethylene glycol ethers of a *p-tert*-octylphenol-formaldehyde cyclic tetramer (with average 60 and 75 ethylene oxide units per phenolic group) (ref. 5).

Table 2. LETHAL ACTION OF ACID ON VARIOUS CELL SPECIES WITH OR WITHOUT 'TRITON *WR*1339'

Cell species	Survival after exposure* at *p*H: 1·2		3·5		5·0		7·0	
	Control	Soap	Control	Soap	Control	Soap	Control	Soap
Myco. tuberculosis (*H37Rv*)	1	6,000	30	8,000	10,000	10,000	10,000	10,000
Myco. phlei	< 1	< 1	2	75,000	—	—	75,000	75,000
Staph. pyogenes	< 1	1	3	20,000	—	—	100,000	100,000
Esch. coli	< 1	< 1	< 1	< 1	—	—	80,000	80,000
Strep. viridans	< 1	< 1	< 1	< 1	3,000	50,000	50,000	50,000
Human red cells	—	—	0	100	100	100	100	100

* For the bacteria, survival is indicated by the viable units/0·02 ml. remaining after exposure for 3½ hr. at 37° C. For the red cells, survival is indicated by the percentage of intact cells remaining after exposure for 3 min. at room temperature.

conditions to those listed, similar protection of tubercle bacilli against the acids perchloric (0·1 *M* to give a final *p*H of 1·2) and phosphoric (*p*H 3·5) was observed. No protection by the soaps against the harmful effects of exposure to alkali has been detected.

So far, we have insufficient evidence to offer an explanation of the mechanism of the protective action of these soaps. There exists, however, a parallel between the protective action and their ability to discharge the colour of fluorescein and similar dyes in acid solutions[8], and this may provide a clue towards the understanding of their action. The failure of solutes such as polyethylene glycol and sucrose to protect would suggest that the protective activity of the soaps is not simply a consequence of the osmotic pressure of their solutions, but rather some specific effect connected with their soap-like properties.

If the phenomenon here reported should be associated with a wide variety of living cells, it might find practical application in certain situations where a temporary and limited protection of cells against acidity is required.

We are indebted to Messrs. Bayer Products, Ltd., London, for supplying 'Triton *WR*1339', and to Dr. J. W. Cornforth and Dr. G. A. Nicholls for preparing the two soaps of the *HOC* series.

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DISTRIBUTION OF ANTISTREPTOLYSINS IN PROTEIN FRACTIONS

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THE relation of immune substances to single protein fractions has been the subject of extensive studies. The recognition of the method of paper electrophoresis by Durrum[1], Grassmann and Hannig[2] and Bockemüller and Rebling[3] and the method of immuno-electrophoresis by Grabar *et al.*[4] has opened new roads in this field. Although the investigations were very extensive, no direct determinations have been published, to our knowledge, concerning the distribution of antistreptolysins in the protein fractions. The method I had formerly employed in studies on the combination of bactericidal agents with protein fractions proved to be very suitable for use in the investigations concerned with the combination of antistreptolysins with those fractions[5].

In studies on the antistreptolysins linked to serum proteins the method has been modified in that the agar was dissolved in a veronal buffer of *p*H 7·4, and

to this were added 1 per cent fresh, thrice-washed sheep erythrocytes. The paper strips containing the protein moved by electrophoresis were placed on them. After paper strips had been cut up and put in place, a streptolysin-0 standard (generously supplied by the Behringwerke, Marburg) dissolved in sodium thioglycollate buffer and containing 20 units per ml. was applied to the paper. This was done by placing a platinum loop full of streptolysin-0 solution on the paper at intervals of 30–35 min. over a period of 4–5 hr. In the intervals the plates were incubated at 37° C. in an incubator to promote the reaction. The results were read 8–10 hr. after the placing of strips and beginning of streptolysin administration. The areas showing hæmolysis after the removal of the paper strips were observed, distinguishing two grades in hæmolysis: total inhibition, when there was no lysed area under the paper; and partial inhibition, when both hæmolysed and non-hæmolysed areas were detectable. The other half of the electrophoretized paper served as the control and after staining was studied by densitometry in an Eppendorf photometer. The extinction values were plotted as a curve. The inhibition of hæmolysis was marked at the appropriate site of the curve and thus the effect of antistreptolysin could be determined accurately.

Sera from normal human subjects and rabbits, as well as from patients showing high antistreptolysin titres (M.I. titre, 1 : 1,100; T.E. titre, 1 : 720) were used. The electrophoretic curves and the corresponding antistreptolysin effects are shown in Figs. 1, 2, 3 and 4.

The columns indicate inhibition of hæmolysis. The shaded columns show total inhibition, the empty

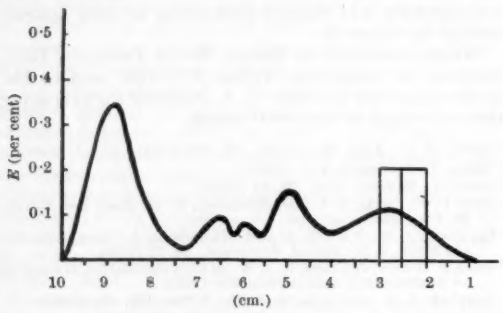

Fig. 1. Normal rabbit serum

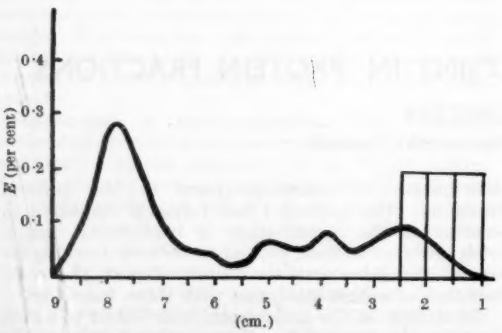

Fig. 2. Normal human serum

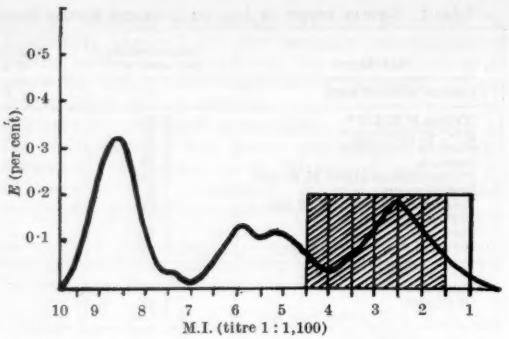

Fig. 3

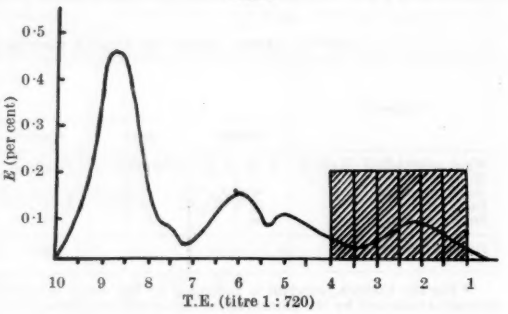

Fig. 4

ones partial inhibition. It is shown by Fig. 1 that the antistreptolysin effect of normal rabbit serum (titre 1 : 10) is bound exclusively to gamma globulin. The main mass of gamma globulin carries this activity, and this lysin inhibition is absent in the ascending and descending branches of the curve. The effect, however, manifests itself in a partial inhibition only. The normal human sera showing antistreptolysin titres as low as 1 : 100 had the same effect (Fig. 2). Here, too, it was exclusively in the area corresponding to the main mass of gamma globulin that an inhibition of hæmolysis, the manifestation of the antistreptolysin effect, was observable. Here, too, inhibition was only partial.

In contrast with this, the high-titre human sera from patients suffering from streptococcal infection behaved quite differently. First of all, the effect was more intense, in so far as here inhibition proved to be complete. Another remarkable finding was that inhibition could be observed also outside the main mass of gamma globulin, in the areas containing a very low concentration of protein migrating faster than gamma globulin. This area of the electrophoretic curve is what is called the area of the fraction *T*. In this area, too, the effect was substantially more marked than in the case of normal sera. A comparison of the curves for the two pathological sera shows a remarkable difference in the gamma globulin-level between the two sera. Although this was very marked, the two sera did not differ substantially in antistreptolysin titre or in the results concerning the fractions studied (Figs. 3 and 4).

These investigations appear to prove beyond doubt that the immune bodies, at least so far as the antistreptolysins are concerned, differ from the normal gamma globulins. Although no data are available as

to their other physical properties, it appears to be unquestionable that these immune bodies migrate at a faster rate than the main mass of gamma globulin. This kind of gamma globulin does not make the immunological significance of gamma globulins questionable, but its existence seems to confirm those experiments in which the immune bodies have been found to be linked not exclusively to gamma globulin[6-8].

Rantz, Rendall and Rantz[9], Imperato[10] and others have reported that a close correlation exists between the level of gamma globulin in serum and the antistreptolysin titre of serum in diseased adults and children. The increase in gamma globulin in such patients can be ascribed to the inflammatory phenomena associated with streptococcal infection and the secondary tissue destruction, rather than to the antistreptolytic activity of sera in such patients. The two curves of the patients offer a strong confirmation of this view, in so far as the immunoantistreptolysins act not only in the area of the gamma globulin but also beyond the main mass of gamma globulin, in the initial part of beta globulin. Considering the amount of serum applied to the paper and the dissociation resulting from migration, it is obvious that only traces of protein can be involved in the effect. This will be even more conspicuous if we take into account also the protein concentration of the interspace between gamma and beta globulin. If we assess planimetrically and by computation the amount of protein contained in the active area on the basis of the quantity of serum applied to the paper (10 mm.^{3}), it will be found that the protein in the interspace between the two fractions corresponds to 1·8 gamma total protein in the case of M.I. and to 0·7 gamma in the case of T.E. This shows clearly how highly active these substances are. Such a high activity is common to the immune reactions in general.

Thus, the experiments with streptolysins have proved beyond doubt that the normal antistreptolysins are different from the immune antistreptolysins, as manifested particularly in a difference in the rate of migration. On the other hand, such minute amounts of protein may suffice to produce a manifest immune effect as cannot be demonstrated in many a case by the highly sensitive reactions, either.

The antistreptolysin studies showed that the antistreptolysin effect of normal human and rabbit sera corresponded to the main mass of gamma globulin. On the other hand, high-titre sera from patients had a very marked effect not only in the area of the main mass of gamma globulin, but also in that between gamma and beta globulin. This evidence suggests that there are apparently two kinds of antistreptolysin, one of which migrates definitely linked to gamma globulin. This occurs in normal sera. The other is an immune body migrating with, and also faster than, the main mass of gamma globulin. This occurs in pathological sera as a result of immunization. The high activity of the substance is shown by the fact that the effect develops also in the presence of very small amounts of protein, as small as 1·8 and 0·7 gamma.

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SPATIAL SUMMATION FOR HEAT-PAIN

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THE experiments of Hardy, Wolff, and Goodell[1], using the radiant-heat technique of focused stimulation, and varying the size of skin surface area exposed to stimulation, showed no threshold variation for pain relative to size of skin area within a range from 0·95 to 28 cm^2. Warmth thresholds were, however, shown to increase more than 200-fold as the area of skin stimulated was diminished from 200 to 0·2 cm^2. The authors therefore concluded that the only cutaneous sensation which does not possess this property is pain, thus distinguishing pain functionally from other sensations, and lending support to their thesis that pain is a sensory modality subserved by a special neural equipment.

Weddell and his associates[2-3], in supporting a 'pattern' theory of non-specific representation in cutaneous sensibility, have put forward two reasons why the evidence refuting spatial summation for pain is not conclusive: (1) Breig[4] is said to have demonstrated spatial summation for the pain caused by drawing a pin across the skin; (2) it has been shown, using a dolorimeter constructed in a manner similar to that of Hardy *et al.*, that there is a 50 per cent fall-off in the intensity of radiation from the centre to the periphery of a 9·6 cm.^{2} area, due to the construction of the filament of the lamp used as the source of radiant energy. Thus a cone of radiant heat is applied to the skin area, so that the heat is not uniformly disposed.

The question, therefore, of whether or not it is possible to demonstrate spatial summation for pain may have some crucial bearing on two major theories of sensibility to cutaneous pain.

In the present study, it was decided to use a water-heating system so as to avoid the technical flaw of the radiant-heat technique. This system consisted of two 4-gallon drums filled with water. The water of one drum was maintained at boiling point throughout the experimental sessions by two immersion-heater elements, the drum being encased with heat-insulating material. The other drum was filled with cold tap-water. A rubber tube was connected to an outlet from the lower part of each drum, the flow of water being regulated by a tap. The outflow of

boiling and of cold water then merged together in a common pipe to a glass connecting tube at the open base of which a circular disk of brass shim, three-thousandths of an inch thick, was securely fixed with heat-resistant glue. A centigrade thermometer was set into the top of the glass connecting tube, standing perpendicular to the horizontal circular disk and with the tip of the mercury bowl almost in contact with it, the rest of the bowl being completely immersed in the hot water. The continuous merging flow of water from the two drums was regulated by the taps until the desired reading on the thermometer was steady.

For the purpose of this experiment, two sizes of circular metal disk were fitted to otherwise identical glass connecting tubes, the one being of 1 cm. and the other of 2 cm. diameter. These disks served as the heat-stimulus contacts for placing on the skin of the volar surface of the subject's left forearm.

Eight adult subjects took part in the experiment, none having prior knowledge of its specific purpose. Each subject was tested on four separate sessions of 45 min., each session being divided into two half-sessions, during one of which the 1 cm. contact was used, and during the other the 2 cm. contact. The order of presentation of the 1 and the 2 cm. contacts was alternated, so that, on sessions one and three, four subjects received the 1 cm. contact stimuli first, and the 2 cm., after a 5-min. interval, during the second half-session; on sessions two and four these subjects received the 2 cm. first and the 1 cm. after the interval. The order of presentation was reversed for the other four subjects. This alternation was intended as a procedural control for any possible serial effect.

The subject was blindfolded before entering the experimental room, so that he could receive no cues from viewing the apparatus. He was instructed to report simply the quality and intensity of the sensation that he experienced during the 3 sec. of exposure of a heated metal contact on his skin. He was given no clue that the metal contacts would differ in size, and he was asked to try to grade the sensations in terms of warmth, heat, pain or no pain, and to retain, as best he could, a consistency in his judgments throughout all the experimental sessions.

The metal contact, attached to a lever, was automatically lowered on to the skin for the 3 sec. exposure period by means of a timing device operating an electromagnet and armature. Until just prior to the 3 sec. period, the contact was kept at a distance of 8 in. above the subject's forearm. It was then lowered to 3 mm. above the skin, a cardboard screen of that thickness being placed between the contact and the skin. This screen was withdrawn immediately prior to the automatic lowering of the contact, which thus fell with a light pressure on the skin, remained there for 3 sec., and at the end was jerked 3 mm. away from the skin and then a further 8 in. above. The minimum interval between successive exposures was 75 sec., and the skin surface area exposed was varied over a distance of 10 cm. longitudinally and 4 cm. laterally. Between 6 and 10 stimuli of varying heat-intensities were applied at each contact-size, and an interval of 5 min. was allowed between the half-sessions, ostensibly as a 'rest' period for the subject during which he went to an adjoining room but in fact to enable the contact-size to be changed. Each subject thus received a total of about 30 heat-stimuli at each contact-size.

The procedure used to arrive at an appropriate narrow range of heat-intensities at, just above, and below the subject's pain threshold was to begin each half-session with a stimulus estimated to fall 2–3° C. below pain threshold. If the sensation reported was of warmth or heat, with no pain, the intensity was increased by steps until pain was first reported. Then stimuli were presented which were close to this 'standard', and an occasional 'check' stimulus at expected 'warmth' intensities only were interspersed to test the reliability of the reporting. It immediately became clear, however, that the intensities required to elicit pain at the 1 cm. size were likely to be several degrees higher than for 2 cm. Skin temperature was continuously recorded from a thermistor placed on the volar surface of the right forearm, but no significant changes were observed in any subjects as between the 1 and 2 cm. test sessions, and there was very little intra-individual variation once the 'steady' level had been reached. Thus differences in skin temperature do not account for the results reported below.

The present stimulation technique was so arranged that the metal contact fell with a light pressure of identical *total* weight for the 1 and 2 cm. sizes. It was thus possible that the difference in pressure per unit area might affect the subjects' reports. For three of the eight subjects, therefore, the 1 cm. contact was fitted with a 'Perspex' ring, making the total contact area on the skin identical to that of the 2 cm. disc. The results obtained with this variation were so closely similar to those obtained on the other five subjects that they have been grouped with these. By placing thermocouples on the contact side of the metal and on the 'Perspex' ring it was found that the latter heated up to a maximum of 36° C. when the metal contact had been maintained for 20 minutes at 50° C.

With this technique and procedure, the results demonstrate consistently and highly significantly

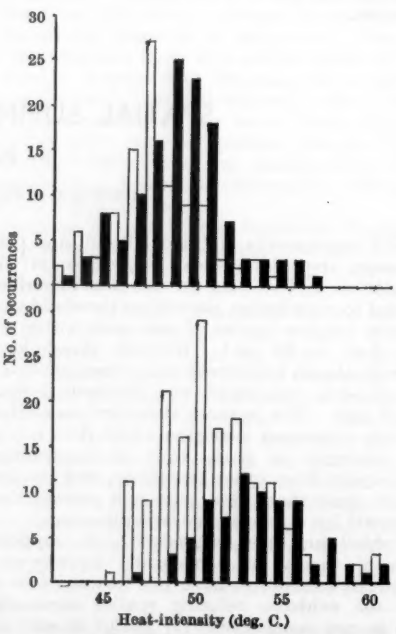

Fig. 1. Histograms showing frequency of occurrence of pain reports (black columns) and no-pain reports (unshaded columns) at various heat-intensities with 2 cm. (upper diagram) and 1 cm. (lower diagram) disks

that there is a spatial summation for heat-pain. The reports made by the eight subjects for the 1 and 2 cm. contacts are summarized in the histograms of Fig. 1, the black columns representing the frequency of reports of pain at the various heat-intensities used, the unshaded columns that of the reports of warmth or heat with no pain.

It will be seen that the frequency of pain-reports over the same range of heat-intensities is considerably greater for the 2 cm. application. Thus if we compare these frequencies over the range from 45·0° C. to 51·9° C., we find pain reported 104 times out of 186 observations (56 per cent) for 2 cm. and only 25 times out of 129 observations (20 per cent) for 1 cm. The χ^2 value of this comparison (42·1) corresponds to $P \ll 0{\cdot}001$.

The consistency of the difference is further emphasized by the fact that seven of the eight subjects reported pain at a lower heat-intensity for the 2 cm. contact on each of their four experimental sessions, the eighth subject once only reporting pain at slightly higher intensity for this contact than for 1 cm. Thus, on 31 out of 32 sessions the threshold for pain was lower with the 2 cm. than with the 1 cm. contact. The mean difference between the 1 cm. and 2 cm. pain thresholds for all the sessions was − 5·0 deg. C.

It would seem, therefore, that spatial summation is as clearly demonstrable for cutaneous heat-pain sensation as it is for other cutaneous sensations, so that in this respect pain can no longer be functionally distinguished from these other sensations. It remains, however, to show the spatial limits within which summation takes place and the exact relationship between heat-intensity and size of area stimulated in this way. It will be necessary also to inquire further into the perceptual aspects of spatial summation, for it is of some interest to record that none of the eight subjects at any time reported awareness of a size-difference between the contacts.

I wish to thank Mr. J. G. Taylor for his suggestions on the apparatus used in this study and Mr. P. Humphris for his careful attention to and skill in dealing with the technical aspects of the research. I am indebted to the Staff Research Fund of the University of Cape Town for a grant towards the cost of the apparatus.

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ROLE OF ROOT INJURY IN PANAMA DISEASE INFECTIONS

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THE *Fusarium* wilt of bananas, commonly called Panama disease, remains one of the major obstacles to be overcome in the cultivation of Gros Michel bananas in the western hemisphere. Although extensive investigations of this malady and its causal agent, *Fusarium oxysporum* f. *cubense* (E. F. Smith) Snyder and Hansen, have been carried out during the past half century, there is no general agreement as to the means by which the fungus enters the host plant. It is generally acknowledged[1] that infection does not occur by way of the pseudostem or the leaves, but it has been suggested[2] that penetration may occur through cuts on the rhizome or true stem. Wardlaw[3], however, has reported that under favourable soil conditions histological reactions within the rhizome tissues prevent significant penetration of the disease organism. In an early description of Panama disease, Brandes[3] presented evidence for penetration through intact tissues of main or primary roots close to the root apex. Wardlaw was unable to obtain root penetration in healthy active roots, but reported infections both of main roots and of lateral rootlets under conditions unfavourable for their active growth[4] or following plasmolysis[5]. He also observed fungus penetration into young main roots decapitated near their tips and studied invasion of trimmed root bases which in some cases led to actual rhizome infections. He considered trimmed root bases, together with insect injuries of the rhizome, as the major sites of infection. More recently Rishbeth[6] described healthy lateral rootlets as the major infection site, and indicated that penetration does not occur directly through the main roots in any circumstances. Finally, Stover[7] has reported that, in agreement with Rishbeth's findings, invasion in Nature occurs at or near the root-cap of lateral rootlets.

In view of the disagreement in the literature, this problem was re-examined here. As experimental material, young Gros Michel banana plants, grown from small seed pieces, were used. Plants to be studied were grown in large clay pots of soil or vermiculite, in root observation boxes having one glass side which was removable, or in a moist chamber. Experimental inoculations were made with three morphologically distinct isolates of *F. oxysporum* f. *cubense* which proved to be equally pathogenic under the conditions used. In some experiments an agar suspension of spores was applied to the roots, and in other cases spores were incorporated into freshly sterilized soil in which the plants were afterwards grown. Infections were studied only in the roots and were identified by the characteristic red or yellow discoloration of the vascular tissue. In all experiments, the pathogen was re-isolated from tissues suspected of infection. Histological studies were made on fresh material by means of hand sections, with supplementary evidence provided by serial sections prepared according to standard procedures[8].

An initial attempt was made to study possible direct infection of main roots as described by Brandes[3]. A heavy spore suspension in molten agar was applied to root surfaces both at the growing tip and in mature regions. No penetration was observed,

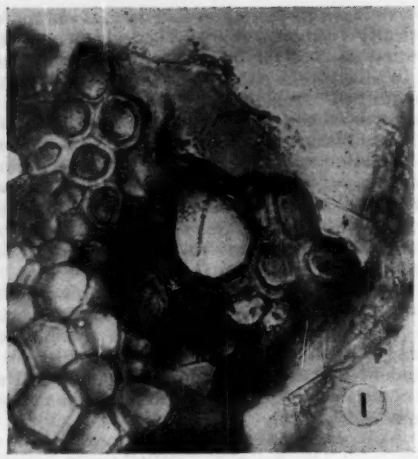


Fig. 1. Transverse section of a main root of a banana plant cut in the region of a deep lateral gash. A suspension of *Fusarium* spores in agar had been applied two days earlier. Hyphæ are visible both inside and outside the exposed vessel (× 275)

and the pathogen gave no evidence, in these experiments, of an ability to attack living cells of the main root. The roots used were growing in sterilized soil and were apparently healthy and vigorous. When, however, injuries were made prior to inoculation, the results were quite different. If in the region of mature tissues a deep lateral gash was made with a scalpel in such a way as to cut the vascular tissues and expose the xylem vessels, rapid (two days or less) penetration of the pathogen into the vessels was observed (Fig. 1). The same result was obtained whether the injury was treated with a spore suspension or whether the roots were merely growing in artificially infested soil (see Table 1). A similarly rapid penetration resulted from needle punctures or scalpel cuts before inoculation, provided that the vascular tissue was involved in the wound. It is interesting to note that shallow gashes or other wounds which did not reach the vascular tissue did not permit entry of the fungus. A layer of cortical parenchyma only two or three cells in thickness appeared to prevent infection completely, further substantiating the earlier observations of the inability of the fungus to attack living cells of the main root. Severing the main root in the mature region also

Table 1. Penetration of Wounded Main Roots of Banana

Type of wound	No. of roots Inoculated	No. of roots Penetrated
Spores in agar. Sterile vermiculite		
Deep lateral gash	9	9
Shallow lateral gash	3	0
Needle punctures	5	5
Knife cuts	5	5
Spores in agar. Sterile soil		
Decapitation near tip	7	0
Decapitation mature region	7	5
Deep lateral gash	9	9
Shallow lateral gash	3	1*
Deep gash near tip	2	0
Artificially infested soil		
Decapitation near tip	9	0
Decapitation mature region	8	3
Deep lateral gash	9	9
Shallow lateral gash	3	0

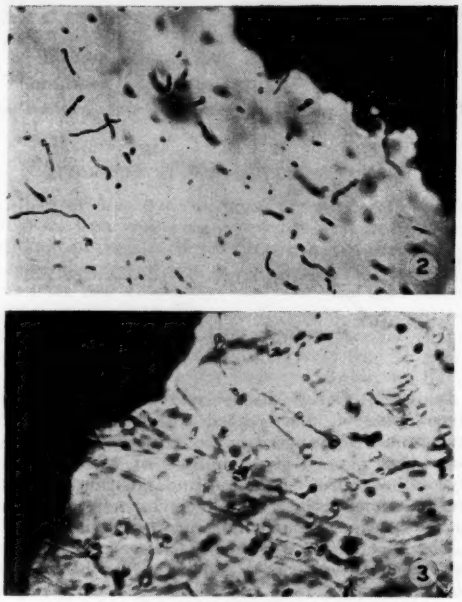
* Histological examination subsequent to the termination of the experiment showed a slight injury to the vascular system.

provided a favourable site of infection, but the results were somewhat less consistent (Table 1). When lateral gashes or decapitations were performed in the immature regions of the root near the growing tip no penetration was observed. It remains to be determined whether rapid wound healing in this region is responsible for the failure or if some other factor, such as inability of the disease organism to penetrate immature vessels, is involved.

The importance of injury in *Fusarium* infections of main roots suggested that a similar condition might well prevail in lateral rootlets, in spite of earlier reports to the contrary. In preliminary experiments it has not been possible to establish with certainty the importance of injury primarily because the extreme fragility of lateral rootlets makes it almost impossible to eliminate injury in any experimental treatment. Experiments were conducted by applying a spore suspension in agar to rootlets, on a restricted region of a main root, or by studying roots growing in infested soil. Injury was produced artificially by clipping rootlets with scissors about midway along their length.

When spore suspensions were applied to supposedly unwounded rootlets, in many cases infection of the main root resulted in the region to which these rootlets were attached. Since, in general, there were no injuries of the main roots in these regions, it was concluded that penetration by way of rootlets does occur. However, as has been pointed out, it was not possible in these experiments to eliminate the factor of rootlet injury. It was quite evident that penetration was of much more frequent occurrence if the rootlets were deliberately injured by clipping. On the other hand, even such deliberate injury did not guarantee infection. The most striking observations were those made on plants growing in infested soil in root observation boxes. After large main roots bearing numerous laterals had developed adjacent to the glass side, this was removed with very little disturbance to the roots and on certain ones rootlets were clipped on one side only. The glass side was then replaced. Three weeks later the roots were removed and examined. Characteristic discolorations caused by the fungus were found only in those main roots the rootlets of which had been clipped and only on the side of the root to which these rootlets were attached. This evidence, while it clearly does not rule out penetration by way of intact rootlets, does suggest that injury may be an important factor in rootlet invasion. An extensive histological study of inoculated rootlets, both wounded and intact, did not reveal the presence of *Fusarium* hyphæ. This is in agreement with the observation of Rishbeth[6] that hyphæ are seen in rootlets only with great difficulty, and it suggests that although hyphæ probably are present in some cases, they do not ramify extensively through rootlet tissue.

In examining wounded main roots to which an agar spore suspension had been applied, a marked difference in extent of germination was noted between spores in proximity to the wounded surface and those in contact with an intact surface. There appeared to be a consistent stimulation of spore germination in the vicinity of a wounded root surface (Figs. 2 and 3). In order to verify the existence of such a stimulatory effect, a suspension of spores in agar was applied to wounded and intact main root surfaces on plants in a moist chamber. Control samples of the suspension were placed on glass slides in Petri dishes in the same laboratory room. When



Figs. 2 and 3. (2) Limited germination in the spore–agar inoculum after three days in contact with an unwounded root surface (right) (× *c.* 330). (3) Extensive germination and mycelial development in the same inoculum shown in Fig. 3 after two days in contact with a lateral gash on the main root. Note marked tropic response towards the wounded surface (left) (× *c.* 330)

spores from the three treatments were examined after twenty-four hours, it was apparent that germination had been markedly stimulated in proximity to the wound in comparison both with the control and with the intact root surface. Moreover, there was a definite inhibition of spore germination, as compared with the control, by the intact root surface. This observation is in striking contrast to the recent report of Jackson[9] that germination of spores of *Fusarium solani* was stimulated by the presence of intact seedling roots. A chromatographic analysis of the materials diffusing from injured banana roots revealed that the factors stimulating *Fusarium* germination and multiplication are amino-acids and, of these, glutamine appears to be the most important.

The observations reported in this article strongly suggest certain conclusions which may be of importance in future studies of Panama disease. In the first place, the current tendency to disregard the main roots as important infection sites must be re-examined in the light of clear evidence of the penetration of these organs when they have been injured. Secondly, the role of injury in Panama disease infections must be considered in all future investigations, not only as a condition making penetration possible but also as a source of influences which bring about a stimulation of the germination of *Fusarium* spores, thereby increasing the likelihood of successful penetration. In studies now in progress it is hoped to provide a critical evaluation of the importance of injury in the penetration of lateral rootlets by the fungus. Moreover, it will be necessary to determine the applicability of the observations reported here to banana plants growing in different circumstances and particularly under field conditions. The frequent occurrence of serious wounds in banana roots in the field, not only on lateral rootlets but on main roots as well, is certainly compatible with the concept of injury as a major factor in Panama disease infections.

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THE REARRANGEMENT OF EPINEPHRINE

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THE study of the enzymatic alteration of a metabolite logically starts from the knowledge of the nature of its electronic configuration and an appreciation of the chemical susceptibilities of the molecule. Such information provides a rational avenue for an investigation into the metabolic pathway. When this approach was applied in a study of the metabolic degradation of the catechol amines, an interesting possibility for a channel of metabolism emerged. I wish to report a rearrangement of epinephrine and norepinephrine of the pinacol–pinacolone type, leading to the formation of 3,4-dihydroxyphenylacetaldehyde. Since this aldehyde is a direct intermediate of 3,4-dihydroxyphenylacetic acid, one of the metabolites which has been reported to be a product from the incubation of norepinephrine with liver slices[1], this rearrangement may represent a chemical model for a further biochemical pathway of catechol amines.

Rearrangement of epinephrine and norepinephrine to 3,4-dihydroxyphenylacetaldehyde. To 200 mgm. of epinephrine or norepinephrine was added 3 ml. of 85 per cent phosphoric acid. (The reaction also proceeds with other strong acids such as 20 per cent hydrochloric acid.) The reaction mixture was heated rapidly to 125° C. for no more than 20 sec. and poured into 30 ml. of water. This solution was extracted twice with 10 ml. of ethyl acetate and the extract was washed with 5 ml. of water. The ethyl acetate of the extract was removed by evaporation with a stream of nitrogen. The residue (62 mgm.) was a clear, highly viscous oil which did not crystallize in the cold. This material was used for making derivatives.

The 2,4-dinitrophenylhydrazone of 3,4-dihydroxyphenylacetaldehyde was recrystallized from ethanol (melting point found, 169–70° C.; melting point lit. (ref. 2), 169–70° C.; analysis for $C_{14}H_{12}N_4O_6$ requires C, 50·60 per cent; H, 3·61 per cent; N, 16·86 per

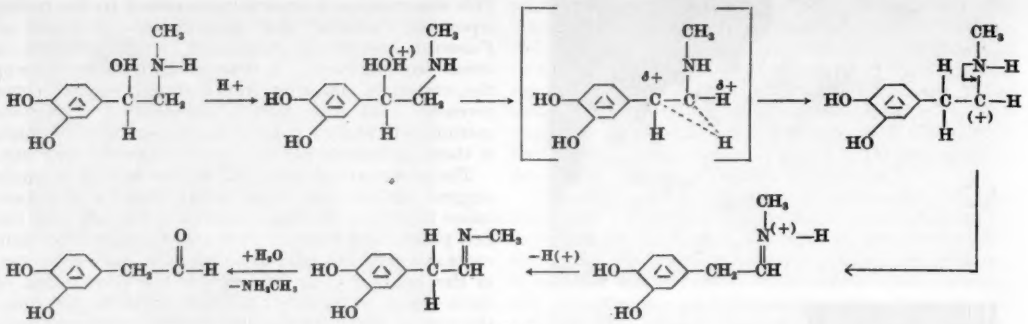

Fig. 1

cent: found C, 50·58 per cent; H, 3·76 per cent; N, 16·60 per cent.). The semicarbazone of 3,4-dihydroxyphenylacetaldehyde was recrystallized from ethanol/water (melting point found, 198–200° C.; melting point lit. (ref. 2), 199–200° C.).

Properties of 3,4-dihydroxyphenylacetaldehyde. This aldehyde appears to be quite stable when stored at − 15° C. It is very unstable in alkaline solution, rapidly turning brown then black to form complex polymeric products. It can be chromatographed on Whatman No. 1 paper in acid solvent, *n*-butanol/1·0 *N* hydrochloric acid, having an ascending R_F of 0·70. The catechol aldehyde exhibits the expected absorption peak in the ultra-violet at 280μ.

The effect of 3,4-dihydroxyphenylacetaldehyde on the isolated rabbit ileum and on the isolated uterus of the rat was determined using the methods described by Burn[3]. It was about 500–1,000 times less active than epinephrine in these systems. With 0·025–0·1 mgm. of the aldehyde per ml., marked relaxation of the isolated ileum and an inhibition of the contraction of the isolated rat uterus induced by acetylcholine was observed.

Holtz *et al.*[4] claimed that when urine, shown to contain oxytyramine, was incubated with tissue in the presence of oxygen a material was produced which had a depressor effect on blood pressure. They assumed that the depressor agent was 3,4-dihydroxyphenylacetaldehyde.

The material, prepared as described above, was tested for its effect on the blood pressure of a dog. The mean arterial blood pressure was determined with a mercury manometer connected to the cannulated femoral artery of animals anæsthetized with 'Nembutal'. Injections of as much as 24 mgm. 3,4-dihydroxyphenylacetaldehyde per 10 kgm. body-weight of the dog had no effect whatever on the dog's blood pressure.

From my observations on the lability of this material it is very unlikely that Holtz *et al.*[4] could have obtained it directly from incubation mixtures under the conditions which they described.

Rearrangement of ephedrine to phenylacetone. 100 mgm. of ephedrine sulphate was treated with 3 ml. of 85 per cent phosphoric acid at 130° C. for 2 min. The sweet odour of phenylacetone was readily apparent. The reaction mixture was poured into 30 ml. of 0·1 per cent 2,4-dinitrophenylhydrazine in 2 *N* hydrochloric acid. The derivative begins to form immediately. The precipitated hydrazone of phenylacetone was recrystallized from ethanol (melting point, 152–53° C. uncorrected; melting point lit. (ref. 5), 152–53° C.).

In 1860, Fittig[6] discovered that when the 1,2-glycol, pinacol, was treated with sulphuric acid, it underwent rearrangement to a ketone, pinacolone. Since that time a large number of substituted 1,2-glycols have been shown to undergo this conversion and reactions of this general type have become known as the 'pinacol–pinacolone rearrangement'.

The mechanism of this rearrangement has been extensively investigated and much has been learned about the aptitude of the various groups to migrate, the nature of the intermediate transition state of the molecule, and the effect of the character of substituent groups on the migrating species.

From the product of the acid-catalysed rearrangement of epinephrine, of norepinephrine, or of ephedrine, one may deduce that a similar mechanism will account for the carbonyl compounds formed.

In this case, as in the general pinacol–pinacolone rearrangement, a proton is added to the hydroxyl-group, which is thus eliminated as a water molecule, leaving a residual positive charge in the form of a carbonium ion. Simultaneously with its formation, the vicinal hydrogen is attracted, producing a positive charge on the adjacent carbon from which the hydrogen has migrated. This carbonium ion attracts electrons from its electronegative neighbour, the amino-group, to form, with a loss of a proton, the unstable imino-group. Hydrolysis of this group to the carbonyl-group takes place as shown in Fig. 1.

A similar explanation for the rearrangement of D-1,2-diphenyl-2-amino,1-anisyl ethanol has been advanced by McKenzie and Mills[7].

In the case of ephedrine either the hydrogen- or the methyl-group could migrate. Since phenylacetone alone was formed in this reaction it is clear that it was the hydrogen that migrated. This is consistent with the observations of other workers that the migratory aptitude of hydrogen is greater than that of any other group[8].

This work was supported by U.S. Public Health Grant No. *H*-2676 and Life Insurance Medical Research Fund Grant *G*-55-44.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Formation of Non-Enzymic Hæm

NEILANDS[1] has described the formation of coprohæm from iron and coproporphyrinogen in aqueous solution at physiological *p*H. Since uroporphyrinogen and coproporphyrinogen, rather than the porphyrins themselves, are now believed to be the true intermediates in the biosynthesis of hæm[2,3], it would be tempting to postulate that protoporphyrinogen is the intermediate which reacts *in vivo* with iron to form protohæm. Further to test this hypothesis, we have incubated aqueous solutions of coproporphyrinogen, coproporphyrin and protoporphyrin with ferrous salts under various conditions and have estimated the hæm formed spectrophotometrically as the pyridine hæmochrome.

Coproporphyrinogen ($1–2 \times 10^{-4} M$) after 16 hr. incubation at *p*H 6 and 37° C. in the presence of large excess of ferrous ions ($1–5 \times 10^{-2} M$) formed a small amount of coprohæm: less than 10 per cent when incubated under nitrogen and much less when incubated in air. However, starting from coproporphyrin, we found up to 25 per cent formation of coprohæm on incubation for 16 hr. at 37° C. under nitrogen and up to 12 per cent on incubation in air. At 100° C. in air the yields from both coproporphyrin and coproporphyrinogen were high and approximately the same. The porphyrinogens are readily oxidized to porphyrins by atmospheric oxygen and the coproporphyrinogen solutions always contained some coproporphyrin, even in those experiments in which incubation was carried out under nitrogen. It cannot be excluded that the formation of hæm observed when coproporphyrinogen was incubated with ferrous iron was derived, in fact, from coproporphyrin.

Protoporphyrin incubated with ferrous salts under the same conditions as were used for coproporphyrin was precipitated from solution and gave no detectable protohæm, but when native globin was added in order to solubilize the porphyrin there was an appreciable formation of hæm (up to 10 per cent with about $10^{-4} M$ porphyrin and $10^{-2} M$ ferrous iron). 'Teepol' (sodium alkyl sulphates) was even more effective; it held both the porphyrin and the ferrous iron in solution at all *p*H values in the range of neutrality (Phillips has used various detergents in order to measure the spectra of porphyrin esters in aqueous media; unpublished work). The yields of protohæm varied from 20 to 45 per cent over the *p*H range 5–8.

A high degree of reproducibility was not possible, particularly in the presence of ferrous hydroxide, which was probably oxidized to varying degrees depending upon small differences in the conditions. Nevertheless, we feel that our results demonstrate clearly that porphyrins and ferrous iron combine under conditions of physiological *p*H and temperature.

In a more complete study of this problem at least two points deserve closer examination. We found that in the presence of 'Teepol' the pyridine hæmochrome of the hæm formed from protoporphyrin had an absorption maximum at 550 mμ in place of 557 mμ. We also found difficulty in getting appreciable incorporation at 37° C. (not at 100° C.) of iron into coproporphyrin formed by the autoxidation of coproporphyrinogen, as opposed to incorporation into coproporphyrin added as such.

Goldberg *et al.*[4] have shown that protoporphyrin will serve as a substrate *in vitro* for an enzyme system forming hæm from nucleated erythrocytes. It seems unlikely that protoporphyrin could be reduced to porphyrinogen by a hydrogenase of avian erythrocytes, since even a powerful reducing agent such as dithionite will not bring about this reduction.

Two distinct stages may be observed in the chemical reduction of porphyrins and in the course of re-oxidation. The fully reduced porphyrinogen (hexahydroporphin) is colourless, but an intermediate stage exhibits a yellow colour and a urobilin-like spectrum with a broad absorption maximum in the region of 500 mμ. This may be a dihydro- or tetrahydro-porphin with a dipyrrylmethene-like structure, and it is of interest that addition of dithionite reduced this intermediate to the colourless porphyrinogen (cf. ref. 3). Such reduction might well be accomplished by a reverse reaction of the erythrocyte dehydrogenases and might constitute the mechanism whereby the porphyrinogen intermediates of hæm synthesis are normally prevented from 'escaping' as uro- or copro-porphyrin, porphyrins which can no longer be drawn back into the system of hæm formation. Indeed, it might be wondered whether in pathological conditions associated with production of excess of free porphyrins, for example, porphyria cutanea tarda[5], some derangement had not occurred in these reducing systems.

From our results, and from these considerations, taken in conjunction with the known ease of entry into the porphin macrocycle of divalent ions such as iron, copper and zinc, we suggest that, in the biological formation of hæm, iron reacts with protoporphyrin, not with protoporphyrinogen.

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Evidence for the Involvement of Ferrous Iron in the Biosynthesis of δ-Aminolævulic Acid by Chicken Erythrocyte Preparations

DURING an investigation into the mode of action of 5 : 6-dimethylbenzimidazole as an inhibitor of δ-aminolævulic acid synthesis in particulate preparations of chicken erythrocytes[1], a range of metal ions was examined for effect on the inhibition. The following metals were without any significant effect: cobalt, copper, nickel, magnesium, manganese, lead and ferric iron. Ferrous iron, however, consistently diminished the inhibition; a typical set of results is shown in Table 1. Addition of ferrous sulphate to freshly prepared systems not containing inhibitor produced a depression of synthesis of δ-aminolævulic acid. If, however, the preparation was aged at

Table 1. Effect of Ferrous Sulphate on the Inhibition of Synthesis of δ-Aminolævulic Acid by 5 : 6-Dimethylbenzimidazole

Incubation conducted under standard conditions (ref. 1) with fresh preparation in the presence of 30 m*M* glycine and 30 m*M* citrate

Additions	δ-Aminolævulic acid (mμ moles)	Stimulation (per cent)
None	180	
Ferrous sulphate (1 m*M*)	106	−41
5 : 6-Dimethylbenzimidazole (2·7 m*M*)	40	
5 : 6-Dimethylbenzimidazole (2·7 m*M*) + ferrous sulphate (1 m*M*)	50	25

Table 2. Effect of Ferrous Sulphate and Ascorbic Acid on Synthesis of δ-Aminolævulic Acid in Fresh and Aged Preparations

Incubations under standard conditions (ref. 1) in the presence of 30 m*M* glycine and 30 m*M* citrate

Additions	δ-Aminolævulic acid (mμ moles)			
	Fresh preparation	Aged 24 hr.	Aged 48 hr.	Aged 72 hr.
None	180	62	31	25
Ferrous sulphate (1 m*M*)	106	59	40	52
Ascorbic acid (1 m*M*)	140	61	34	37

0–4° C. for periods exceeding 24 hr., then significant stimulations were obtained. Up to periods of 72 hr., the stimulation increased in magnitude with progressive ageing. Table 2 is typical of results obtained in this way.

The implication of these findings appeared to be that ferrous iron is involved at some stage in the synthesis of δ-aminolævulic acid but that, on ageing, it is progressively oxidized to the ferric state, which has been found to be devoid of stimulatory activity. If this hypothesis be correct, addition of a suitable reducing agent to aged preparations would be expected to have the same effect as addition of ferrous salts. That this is in fact the case was verified by use of ascorbic acid. As in the case of ferrous sulphate, no stimulation was obtained with fresh preparations (see Table 2). The depression of synthesis of δ-aminolævulic acid in fresh preparations by ferrous sulphate is reminiscent of the observation that several microorganisms which synthesize porphyrins (via δ-aminolævulic acid) require small amounts of iron but that larger amounts are inhibitory (see, for example, Pappenheimer[2]). That it was not due to the sulphate anion was shown by including controls containing potassium sulphate.

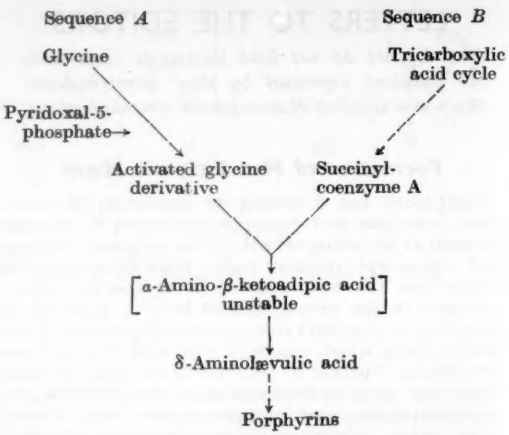
Further evidence that ferrous iron is involved was obtained by demonstrating inhibition of synthesis of δ-aminolævulic acid in the presence of α-α′-dipyridyl, a potent chelating agent for ferrous iron. This inhibition could be reversed by addition of ferric sulphate (Table 3).

Table 3. Inhibition of Synthesis of δ-Aminolævulic Acid by α-α′-Dipyridyl and its Reversal by Ferrous Sulphate

Incubations under standard conditions (ref. 1) with preparation aged for 48 hr. Substrates glycine (30 m*M*) and citrate (30 m*M*)

Additions	δ-Aminolævulic acid (mμ moles)
None	51
α-α′-Dipyridyl (1 m*M*)	41
α-α′-Dipyridyl (1 m*M*) + ferrous sulphate (1 m*M*)	50
Ferrous sulphate (1 m*M*)	80

The current conception of the early stages of porphyrin biosynthesis, of which δ-aminolævulic acid is an intermediate, may be represented as follows:



As 5 : 6-dimethylbenzimidazole inhibits somewhere[1] in sequence *A*, and in view of the relationship of this substance to stimulation by ferrous iron, it would seem likely that ferrous iron exerts its stimulatory capacity in the steps comprising sequence *A*. Preliminary experiments in which production of succinyl–coenzyme A was assayed in control aged systems and in aged systems stimulated with ferrous sulphate confirm this, ferrous iron producing no stimulation but in fact slightly inhibiting sequence *B* (see Table 4).

Table 4. Comparison of the Effects of Ferrous Sulphate on Yield of δ-Aminolævulic Acid and Production of Succinohydroxamic Acid under Comparable Conditions

Incubations conducted under standard conditions (ref. 1) with 48-hr. old preparations. Incubates for estimation of δ-aminolævulic acid contained glycine (30 m*M*) and citrate (30 m*M*). Those for estimation of hydroxamic acid by the method of Lipmann and Tuttle (ref. 7) contained 40 m*M* hydroxylamine but neither glycine nor pyridoxal-5′-phosphate

Additions	Succinohydroxamic acid (mμ moles)	δ-Aminolævulic acid (mμ moles)
None	550	54
Ferrous sulphate	410	99

By analogy with other pyridoxal-5′-phosphate systems, it seems likely that glycine is activated by the formation of Schiff's base with pyridoxal-5′-phosphate (the involvement of the latter in the formation of δ-aminolævulic acid having been demonstrated by Schulman and Richert[3]) and that a metal may be involved in stabilizing the base by chelation. This may well be the site of action of the stimulation by ferrous iron. Evidence has been presented recently by Patwardhan[4] that ferrous iron might be involved in the reaction mechanism of glutamic-oxaloacetic transaminase, another pyridoxal-5′-phosphate system.

That iron is involved in the synthesis of porphyrins has been suggested previously. Duesberg[5], for example, demonstrated decreased porphyrin excretion in patients with iron deficiency. Further, Heilmeyer and Plöttner[6] reported that intravenous injection of ferrous ascorbate leads to synthesis of hæmoglobin in excess of that calculated for complete utilization of the iron supplied. Pappenheimer[2] has shown that synthesis of porphyrin in *Corynebacterium diphtheriae* is stimulated by iron (ferrous sulphate) in concentrations up to 0·1 mgm./l. of culture medium, although concentrations in excess of this are inhibitory. Again, it has been known for many years that iron is required for the synthesis of chlorophyll in

plants, although chlorophyll itself does not contain this metal. δ-Aminolævulic acid, however, is an intermediate of this biosynthetic process[8]. Further work on these observations is in progress and will be reported in full elsewhere.

I wish to thank Prof. C. Rimington for his interest and advice and Miss B. Knight for technical assistance during the course of this work, which was carried out during the tenure of an I.C.I. Research Fellowship.

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Effect of Copper Deficiency on Synthesis of Hæm

Although copper is essential for the formation of normal hæmoglobin, it has not been demonstrated that this element functions directly in the synthesis of hæm. We have demonstrated an increased synthesis of hæm *in vitro* from glycine labelled with carbon-14, by means of adding inorganic copper to copper-deficient chicken blood.

Cross-bred chicks from a commercial hatchery were rendered deficient in copper in two weeks by feeding the following diet: non-fat milk solids, 55 per cent; glucose-monohydrate, 40 per cent; cotton-seed oil, 2 per cent; glycine, 0·6 per cent; L-arginine monohydrochloride, 0·5 per cent; L-cystine, 0·2 per cent; choline chloride, 0·6 per cent; and sodium chloride, 0·5 per cent. In addition, each 100 gm. of diet contained 2 mgm. of nicotinic acid, 240 I.U. of vitamin A-palmatate, 12·4 mgm. magnesium sulphate, 1·9 mgm. manganese sulphate and the equivalent of 14 mgm. carbonyl iron (General Aniline Works, Grasselli, New Jersey). The iron was fed in the carbonyl form in experiments 1, 2 and 3 and in the chloride form in experiments 4, 5 and 6. The control diets were supplemented with 1·6 mgm. of copper sulphate per 100 gm. of diet. The criteria for deficiency in copper were reduced growth-rate and hæmoglobin concentration.

To determine the effect of a deficiency of copper on synthesis of hæm, 0·1 ml. of a solution of glycine containing 1 μc. methylene-labelled glycine and sufficient non-labelled glycine to yield a final concentration of $1·33 \times 10^{-2}$ *M* was added to either 3 or 5 ml. of heparinized whole blood. In addition, antibiotics[1] and 0·1 ml. of a ferrous sulphate solution were added to yield a final concentration of 2×10^{-4} *M*, as recommended by Dresel and Falk[2]. All samples were incubated at 37·5° C. under an oxygen atmosphere in a Warburg apparatus for 24 hr. Hæm was isolated and recrystallized according to the method of Shemin *et al.*[1], except that strontium chloride was used instead of sodium chloride. A large excess of carrier hæm was added in experiments 2, 3, 4 and 6 but not in experiments 1 and 5. In each experiment blood samples from 4–10 chicks were pooled and incubated either with or without supplemental copper sulphate to a final concentration of $1·6 \times 10^{-5}$ *M*.

Table 1. Effect of Copper on Synthesis of Hæm in Blood deficient in Copper

Experiment*	Treatment†	Weight gain‡ (gm.)	Hb (gm. per cent)	Specific activity of hæm −Cu	Specific activity of hæm +Cu	Standard error of the mean $S_{\bar{x}}$	Significant level of the copper effect
1	Control	68·8	7·35	37·8	37·7	±3·5	0
	Cu-def.	34·5	3·70	12·1	29·0		0·01
2	Control	62·0	6·52	9·4	7·9	±0·6	0
	Cu-def.	36·4	4·25	6·7	9·3		0·05
3	Control	62·0	5·78	2·3	3·3	±0·2	0·05
	Cu-def.	36·4	4·25	1·9	2·5		0·05
4	Control	69·8	8·39	8·0	7·9	±0·6	0
	Cu-def.	39·9	5·18	8·7	11·1		0·01
5	Control	95·0	6·33	39·1	27·9	±0·8	0·01
	Cu-def.	66·0	3·57	24·9	23·7		0
6	Control	69·8	8·39	4·3	1·6	±0·4	0·01
	Cu-def.	39·9	5·18	3·8	3·6		0

* Results in experiments 1, 2 and 3 are from chicks fed carbonyl iron. Results in experiments 4, 5 and 6 are from chicks fed iron chloride.
† Control diet contained 1·6 mgm. copper sulphate per 100 gm. of diet.
‡ The weight gains in experiment 5 are for four weeks and all others are for two weeks.

The results in Table 1 show that in blood from chicks deficient in copper and fed the diet containing carbonyl iron, synthesis of hæm was reduced, but the addition of copper to this blood consistently increased this synthesis. Blood obtained from chicks deficient in copper and fed iron chloride, however, gave an increased synthesis of hæm in the presence of copper only in experiment 4. With the exception of experiment 3, the addition of copper to the blood from control chicks failed to increase the synthesis of hæm. This exception may possibly be related to the low concentration of hæmoglobin in the control chicks of this experiment.

The results obtained in these experiments demonstrate that copper has a direct function in the synthesis of hæm. From the fact that the copper effect was obtained consistently only when carbonyl iron—a source of iron of low availability—was used in the diet, it appears that a dual copper–iron deficiency may be essential to demonstrate the effect of copper on the *in vitro* synthesis of hæm.

Experiments are in progress to determine the site(s) of copper activity in the synthesis of hæm. Recently, Iodice, Richert and Schulman[3] have demonstrated that δ-aminolævulinic acid dehydrase contains copper and that its activity is reduced in copper-deficiency. It is possible, however, that copper has functions in the synthesis of hæm other than in connexion with this enzyme and the system described here should prove beneficial in elucidating the role of copper in the synthesis of hæm.

We wish to thank Dr. C. H. Hill for providing the chicks used in these experiments and for his aid and advice in the care and feeding of them. This project was partially supported by a grant from the Frasch Foundation.

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Effect of Gamma-Radiation on Ferriprotoporphyrin

In dilute aqueous solution the oxidized prosthetic group of hæmoglobin and catalase, ferriprotoporphyrin (the ferric iron derivative of 1,3,5,8-tetramethyl-2,4-divinylporphine-6,7-dipropionic acid) may be affected by ionizing radiation at several places in its complex structure. Dale and Russell[1] and Barron and Johnson[2] observed spectroscopic changes which led them to conclude that the porphyrin ring was broken. In addition, Barron and Johnson found that in the absence of oxygen the spectrum was changed to that of a ferroprotoporphyrin. We have obtained spectroscopic evidence that a new compound is produced before the ring is broken, and that the vinyl side-chains play an important part in its formation. It is also found that hydrogen peroxide will produce this compound.

Irradiation of an aerated 10^{-5} *M* solution of ferriprotoporphyrin in 0·1 *N* sodium hydroxide with 15,000 r. of γ-rays from a cobalt-60 source results in a shift of the visible absorption peak from 612 mμ to 600 mμ and in a small decrease in its intensity. The visible absorption spectra have isosbestic points at about 415, 495, 560, 605 and 640 mμ, which suggests that the reaction is one in which one coloured compound is being changed into another single-coloured compound. Above 15,000 r. a general decrease in intensity of the entire visible absorption spectrum is observed. As the visible spectrum changes during the initial period of radiation, a rapid non-exponential decrease of about 28 per cent in the Soret peak (at 385 mμ) also occurs; this is followed (above 15,000 r.) by a less rapid, exponential decrease. The rate curve based on the decreased absorption of the Soret peak is typical of two consecutive first-order reactions in which compounds *A* and *B* possess the property which is being measured, and *C* does not, and in which the rate of conversion of *A* to *B* is much faster than of *B* to *C*. These observations are in accord with an initial reaction in which a compound, *B*, with an intact porphyrin ring, is produced, followed by reactions resulting in a rupture of the porphyrin ring structure.

Further evidence that compound *B* is an iron porphyrin pigment can be found in its reaction with pyridine. The compound with the absorption band at 600 mμ and the less intense Soret peak at 385 mμ was precipitated by acidifying the alkaline solution, and the precipitate was dissolved in 25 per cent aqueous pyridine. The absorption spectrum of this solution had peaks characteristic of a pyridine ferriprotoporphyrin. When dithionite was added, the spectrum changed to one having visible band maxima at 522 and 554 mμ and a Soret peak at 417 mμ. This spectrum resembles that of pyridine ferroprotoporphyrin, which has visible band maxima at 525 and 556 mμ, and a Soret peak at 420 mμ. It was shown that the new compound was stable to treatment with pyridine by acidifying the pyridine solution, thus precipitating a pigment, the visible absorption spectrum of which in 0·1 *N* sodium hydroxide was identical with that of the 600 mμ compound. Application of this procedure to pyridine ferroprotoporphyrin itself yields ferriprotoporphyrin.

Treatment of alkaline ferriprotoporphyrin with about an equimolar amount of hydrogen peroxide results in changes in the visible and ultra-violet spectra which are difficult to distinguish from those produced by 15,000 r. of γ-radiation. A gradual change in the spectrum could be followed using fractional equivalents of hydrogen peroxide. Isosbestic points were observed at the same positions as in the radiation reaction. Much larger amounts of hydrogen peroxide did not change the position of the bands, but did cause the very slow general decrease in the intensity of the visible and Soret regions of the spectrum reported by Lemberg and Legge[3]. There seems to be little doubt that the reaction of alkaline ferriprotoporphyrin with dilute hydrogen peroxide is closely analogous to that produced by low doses of γ-radiation. Dilute potassium permanganate also reacts with alkaline ferriprotoporphyrin in a similar manner, shifting the 612 mμ peak to 600 mμ.

Evidence of the importance of the vinyl groups of ferriprotoporphyrin on the production of the new compound was obtained by comparative studies with ferrideuteroporphyrin. Irradiation of dilute alkaline solutions of ferrideuteroporphyrin (the ferric iron derivative of 1,3,5,8-tetramethylporphine-6,7-dipropionic acid) prepared by melting ferriprotoporphyrin with resorcinol to remove the side chains in the 2 and 4 positions[4], caused no shifts in the peaks of the visible absorption spectrum, and the decrease in the Soret peak approximates to that of a single first-order reaction. The rate for doses to 10^5 r. is approximately the same as that for a ferriprotoporphyrin solution of the same initial concentration from 15,000–10^5 r. These observations suggest that the initial effect of γ-irradiation on ferrideuteroporphyrin, unlike that on ferriprotoporphyrin, results in a rupture of the porphyrin ring structure. It clearly follows, then, that the vinyl side chains are necessary for the formation of the new compound from ferriprotoporphyrin. Whether they act by activating some other part of the porphyrin molecule, or whether they take part directly in the radiation reaction, or possibly both, however, remains a subject for further research.

This work was performed under Contract *AT*–04–1–*GEN* 12 between the Atomic Energy Commission and the University of California, Los Angeles.

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A New Series of Leishmanicides

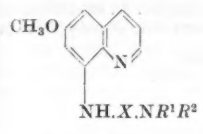
The first synthetic antimalarial that found a place in medicine was pamaquin (plasmochin), which is an 8-aminoquinoline derivative (I; $X = CHCH_3.[CH_2]_3$; $R^1 = R^2 = C_2H_5$), and since its discovery more than twenty-five years ago[1] many examples of the class have been prepared, of which some exceed pamaquin in antimalarial activity.

We have now found that a closely defined group of compounds of this class (patent applications pending) possess the rare attribute of chemotherapeutic

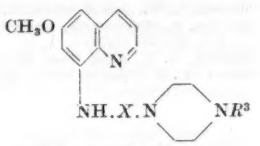
activity against *Leishmania*, the protozoan parasite which causes kalar-azar and oriental sore.

The substances were tested in hamsters infected with several strains of *Leishmania donovani* by the methods described by Goodwin[2,3]. The active members of the series were more effective than quinquevalent antimonials and aromatic diamidines when given subcutaneously, and unlike the other leishmanicidal drugs, they are also active when given orally.

The essential structural criterion is that piperazino shall be the terminal basic group in place of NR^1R^2, the active class being represented by (II) in which X is a straight or branched alkylene chain.



(I)



(II)

The consequential introduction of a further basic centre is not itself the decisive feature in that compounds such as (I; $X = [CH_2]_2.NH.[CH_2]_2$) are inactive, as indeed are those with other basic terminal rings (for example, morpholino, piperidino, pyrrolidino). Compounds of this class with 5 : 6-dimethoxy and those in which the 6-methoxy- is replaced by a 6-hydroxy- or a 6-ethoxy-group are also active, but 6-chloro- and 6-unsubstituted compounds are without significant activity. A wide variation of the alkylene group X is permitted, and activity is notably high for $X = [CH_2]_3$. Activity is maintained with a variety of N-substituents of the piperazine ring, and is high for $R^3 = H$ or alkyl; compounds with hydroxyalkyl in this position are also very effective. Compounds with substituents in this position, such as CO_2Et, $CO.NEt_2$ or aryl, that suppress or greatly reduce the basic character of the terminal nitrogen atom, are usually inactive.

Some members of the series possess high activity against *Plasmodium gallinaceum* in chicks.

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The Morphinized–Eserinized Leech Muscle for the Assay of Acetylcholine

The use of the eserinized dorsal wall of the leech as an assay object for acetylcholine has proved unsatisfactory in the past because of inadequate relaxation and decreasing sensitivity in most preparations.

As Paton *et al.*[1] had shown that morphine decreased the output of acetylcholine in the electrically stimulated ileum of the guinea pig, it was decided to investigate the influence of morphine on the relaxation of the eserinized leech. Morphine was found to facilitate relaxation and in a suitable concentration (4 or 5×10^{-5} gm./ml.) did not appreciably decrease the sensitivity to acetylcholine. In a higher concentration (10^{-4} gm./ml. or greater) it depressed the response to acetylcholine as had been previously described by other workers[2].

The dorsal wall was cut longitudinally and horizontally to give four strips. The magnification was 20-fold and the tension equivalent to 2 gm. The composition of the oxygenated Ringer solution was as follows: sodium chloride 9, potassium chloride 0·42, calcium chloride 0·24, sodium bicarbonate 0·15 and dextrose 1 gm. in 1·4 litres of distilled water. The *p*H was 7·3.

Initially the leech strip was immersed in morphine sulphate (4 or 5×10^{-5} gm./ml.)–Ringer and left until adequately relaxed, usually 3 hr. or less, the lever being tapped occasionally. The strip was then immersed in morphine (4 or 5×10^{-5} gm./ml.)–eserine sulphate (10^{-5} gm./ml.)–Ringer for 30 min. before commencing an assay. The eserine usually caused only a slight contracture. The morphine–eserine–Ringer was used for washing throughout. As the test solutions consisted of mammalian–Ringer perfusates containing 10^{-5} gm./ml. eserine, which were diluted with distilled water (10–14 ml.) before assay, acetylcholine was applied in eserine (7×10^{-6} gm./ml.)–Ringer and allowed to act for 1½–3 min. The preparation was washed two or three times and relaxation was facilitated by tapping the lever. Suitable assays were carried out in twenty experiments on eighty strips. On most strips the threshold concentration of acetylcholine was 10^{-9} gm./ml. Occasionally it was $1·5 \times 10^{-9}$ gm./ml. and in two $0·5 \times 10^{-9}$ gm./ml. In no case did the sensitivity fall off during a 3–5 hr. assay. Smoking during an assay did not appear to interfere with relaxation. In one experiment in which the strip was immersed in Ringer containing 7×10^{-6} gm./ml. eserine with the morphine proportionally reduced (3×10^{-5} gm./ml.), the sensitivity to acetylcholine was decreased. Evidently the concentration of eserine and morphine is critical.

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A Reduced Diphosphopyridine Nucleotide Oxidase in Lettuce Seeds

Various enzymes oxidizing reduced diphosphopyridine nucleotide by pathways other than the cytochrome system have been described. Kern and Racker[1] indicated an oxidase dependent on a product of the oxidation of ascorbic acid, and Nason *et al.*[2] have shown the existence of a nucleotide–quinone reductase. Mapson and Moustafa[3] have shown the oxidation of reduced triphosphopyridine nucleotide by an enzyme linked to glutathione, while Kersten *et al.*[4] have demonstrated the existence of an oxidase dependent on ascorbic acid. Hackett[5] has shown that the ascorbic acid oxidase of potato tubers can oxidize reduced diphosphopyridine nucleotide. Dry lettuce seeds seem to contain an enzyme which does not correspond to those previously described.

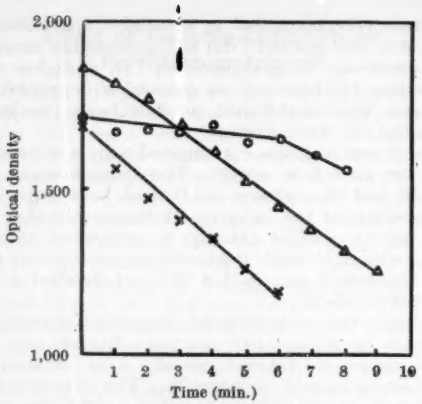

Fig. 1. The oxidation of reduced diphosphopyridine nucleotide in the presence and absence of ascorbic acid. ×, No ascorbic acid added; ○, 0·1 mgm. ascorbic acid/cuvette; △, extract pre-incubated with 0·1 mgm. ascorbic acid for 7 min. before adding reduced diphosphopyridine nucleotide. (Each cuvette contained 1·5 ml. phosphate buffer *p*H 6·3, 0·1 *M*, 0·1 ml. reduced diphosphopyridine nucleotide 0·25 per cent, 0·05 ml. extract and water to 3 ml.)

Extracts of lettuce seeds contain an enzyme which readily oxidizes reduced diphosphopyridine nucleotide without any added hydrogen acceptor. Enzyme activity was followed spectrophotometrically at 340 mμ. The enzyme was not precipitated at 20,000*g* from phosphate–sucrose buffer. The ability of the enzyme to oxidize reduced diphosphopyridine nucleotide was not increased by the addition of cytochrome *c*, reduced or oxidized glutathione, benzoquinone, dihydroxyphenylalanine or dehydrascorbic acid. However, small amounts of ascorbic acid completely inhibited the activity of the enzyme. As the ascorbic acid was destroyed by ascorbic acid oxidase present in the extracts, this inhibition was overcome, but without any increase of activity over corresponding controls (Fig. 1). Thus it appears that no intermediary of the oxidation of ascorbic acid was involved in this reaction. The active extracts also had high dihydroxyphenylalanine oxidase activity. The latter was followed spectrophotometrically at 500 mμ. Both reduced diphosphopyridine nucleotide oxidase and dihydroxyphenylalanine oxidase were inhibited by thiourea and diethyldithiocarbamate. Inhibition of the two systems was similar but not identical. This suggested that the reduced diphosphopyridine nucleotide oxidase is an enzyme containing copper. That it is not ascorbic acid oxidase is shown by its very different sensitivity to thiourea, since this is totally inhibited by $1{\cdot}4 \times 10^{-4}$ *M* thiourea, while the reduced diphosphopyridine nucleotide oxidase is totally inhibited only by $1{\cdot}3 \times 10^{-3}$ *M* thiourea. Moreover, ascorbic acid oxidase activity rises with increasing time of germination of the lettuce seeds[6], while reduced diphosphopyridine nucleotide oxidase activity falls in the same circumstances. Dihydroxyphenylalanine oxidase activity shows a similar fall in activity. After acetone fractionation, both reduced diphosphopyridine nucleotide oxidase activity and dihydroxyphenylalanine oxidase activity appeared in the same fraction. However, the latter decreased on fractionation, indicating either partial inactivation or some special co-factor requirement. These results suggest that the same enzyme may oxidize both reduced diphosphopyridine nucleotide and dihydroxyphenylalanine. This possibility as well as the co-factor requirement of the enzyme and its physiological importance in lettuce seeds are being investigated. It appears that the enzyme described is not identical with the soluble reduced diphosphopyridine nucleotide oxidases described by other workers[1–4]. Fuller details of this work will be reported elsewhere.

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Hypoglycæmic Effect of Monoiodoacetic Acid and Iodoacetamide in Rats

Alloxan lowers the concentration of reduced glutathione in the blood of the rat, but apparently has no effect on reduced glutathione in this animal's pancreatic tissue when the exocrine parenchyma has atrophied as a result of a duct ligation[1]. Nor does it seem to have any effect on the principal islets in certain species of fish[2]. Since alloxan, in both these cases, has a diabetogenic effect the observations seem to suggest that the diabetogenic effect of alloxan is not due to the inhibition of enzymes containing free sulphydryl groups in the β-cells of the islets of Langerhans[3].

Monoiodoacetic acid and iodoacetamide, when administered to rats, lower reduced glutathione in the blood and in pancreatic tissue atrophied as a result of duct ligation[4]. The effect exerted by these substances on blood sugar and the cells of the islets of Langerhans has been studied in rats. First, by the administration of a single dose subcutaneously (monoiodoacetic acid, 0·05 gm./kgm. body-weight, and iodoacetamide, 0·03 gm./kgm. body-weight), and secondly, by giving a daily dose of 0·005–0·01 gm./kgm. body-weight over a period of 15 days. The blood

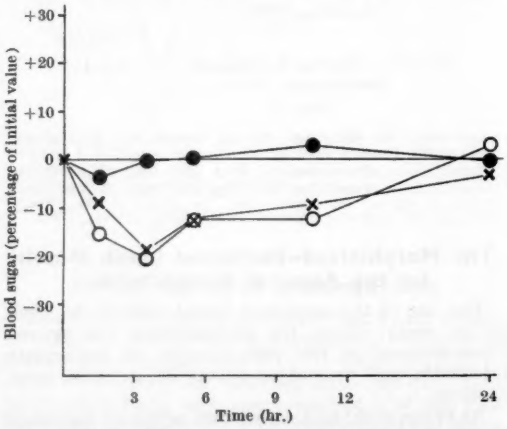

Fig. 1. Blood sugar changes, in percentage of starting value, after single administration of monoiodoacetic acid and iodoacetamide. ●—●, Control animals receiving physiological salt solution; ×—×, animals receiving monoiodoacetic acid; ○—○, animals receiving iodoacetamide

Table 1. KARYOMETRIC INVESTIGATION OF α- AND β-CELLS IN THE ISLETS OF LANGERHANS. NUCLEAR SURFACE IN μ^2. FIGURES IN BRACKETS REFER TO PROBABILITIES

	Monoiodoacetic acid		Iodoacetamide		Control animals	
	α-cells	β-cells	α-cells	β-cells	α-cells	β-cells
Single dose					25·5	28·8
3 hr. after injection	25·4	29·9	26·7	31·0 (0·05–0·01)		
6 ,, ,, ,,	28·4 (0·05–0·01)	32·3 (0·01–0·001)	28·6 (0·05–0·01)	31·7 (0·05–0·01)		
12 ,, ,, ,,	26·4	31·2 (0·01)	25·8	32·5 (0·001)		
24 ,, ,, ,,	25·3	31·9 (0·01)	26·0	31·8 (0·001)		
48 ,, ,, ,,	25·0	27·3	26·1	28·2		
Daily doses 15 days	25·7	27·7	24·1	27·9	26·9	27·5

sugar was determined by Hagedorn and Jensen's method, and the pancreas was stained with chrom-hæmatoxylin–Ponceau–fuchsin after fixation in Bouin's fluid. The nuclear size of the α- and β-cells was determined with a planimeter after the cells had been sketched at a magnification of approximately 1,700.

After the single dose of monoiodoacetic acid and iodoacetamide (Fig. 1) the blood sugar decreased, reaching its lowest value 3–4 hr. after the injection and returning to its original concentration within 24 hr. of the injection. A certain increase in the values noted a few days after the injection of monoiodoacetic acid could not be statistically demonstrated. After the administration of iodoacetamide the blood sugar values 2–3 days after the injection were lower than those for the control animals, but not lower than the starting value. No permanent increase in blood sugar was observed. When the substances were administered daily, neither hyperglycæmia nor glycosuria developed.

Microscopic examination of the pancreas at varying intervals after the injection did not reveal any necrosis in either of the cell forms in the islets; nor was any pyknosis observed in the nuclei of the islet cells. Great variability in the stainability and granulation, such as is seen in connexion with heightened function, was observed in both α- and β-cells during the 24 hr. immediately following the injection. The result of the karyometric examination can be seen in Table 1. Both forms of islet cells displayed nuclear enlargement, suggesting that increased activity was in progress. This activity persisted, in the β-cells, almost throughout the first 24 hr. after the injection, whereas in the α-cells the disturbance was of short duration. No change in nuclear size could be demonstrated after 24 hr. or after 15 days of continuous administration.

These studies have not revealed anything to indicate that monoiodoacetic acid and iodoacetamide are diabetogenic in the doses used, despite the fact that, in certain respects, they exert a stronger effect on sulphydryl substances than alloxan. The reason for the decrease in blood sugar observed after the injection of monoiodoacetic acid and iodoacetamide seems to lie in the increased β-cell activity which, to judge from the karyometric findings, arises after injection of the single dose. Nothing definite was observed to indicate damage to the α-cells.

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Species Difference in regard to the Biosynthesis of Ascorbic Acid

IN previous reports[1,2] from this laboratory, it has been shown that the liver tissue of mammals such as the cow, goat and rat (but not the guinea pig) could produce strikingly large amounts of ascorbic acid *in vitro* with D-glucuronolactone as substrate in presence of cyanide. This did not occur in the absence of cyanide, and no other substrate except L-gulonolactone was effective. It was, however, found[1,2] that the liver tissue of birds such as the chicken and the pigeon, which are known to synthesize their own requirements of ascorbic acid, failed to synthesize ascorbic acid under these conditions. Grollman and Lehninger[3] have meanwhile shown by their method that, as opposed to mammals, the capacity for synthesizing ascorbic acid in the birds and reptiles they studied, namely, the chicken, pigeon and tortoise, resides in the kidney tissues.

It was of interest to study, by our technique using cyanide, the capacity of different species of animals, including amphibians, reptiles, birds and mammals, to synthesize ascorbic acid. Table 1 shows the results obtained.

Table 1. NET SYNTHESIS OF ASCORBIC ACID (μGM.) BY THE KIDNEY AND LIVER TISSUE HOMOGENATES

The test system contains 0·07 *M* phosphate buffer (*p*H 7·4), 0·025 *M* substrate, tissue homogenate (250 mgm.), 0·05 *M* potassium cyanide in a total volume of 5·0 ml. incubated for 2 hr. at 37·5° C.

Animal	Species	Kidney	Liver
Amphibians:			
Common Indian toad (in summer)	*Bufomelanostictus schneider*	370	0
(in winter)	,,	235	0
Reptiles:			
Bloodsucker	*Calotes versicolor* Daudin	185	0
Common Indian monitor	*Varanus monitor* (Linn.)	184	0
Birds:			
Common pochard	*Aythya ferina* (Linn.)	188	0
Chicken	*Gallus gallus*	263	0
Grey partridge	*Francolinus pondicerianus* (Gamelin)	218	0
Coot	*Fulica atra* (Linn.)	241	0
Pigeon	*Columba livia* (Gamelin)	330	0
Owl	*Otus bakkamoena pennant*	250	0
Kingfisher	*Halcyon smyrnensis* (Linn.)	72	0
House crow*	*Corvus splendens splendens* (Vieillot)	32	128
Common myna*	*Acridotheres tristis* (Linn.)	15	64
Munia*	*Lonchura malacca* (Linn.)	0	93
Bank myna*	*Acridotheres ginginianus* (Latham)	0	86
Hill myna*	*Gracula religiosa* (Linn.)	0	73
Magpie robin*	*Copsychus saularis* (Linn.)	0	56
Tree-pie*	*Crypsirina vagabunda* (Latham)	0	38
Red-vented bul-bul*	*Pycnonotus cafer* (Linn.)	0	0
Mammals:			
Indian fruit bat	*Pteropus medius*	0	0
Rat		0	90

* Passeriformes.

It will be seen from Table 1 that both amphibian and reptile kidney tissues, but not their liver tissues, could synthesize ascorbic acid. The lower value of ascorbic acid obtained with the toad tissue in winter compared with summer is apparently due to its lower metabolism during hibernation in winter. In the cases of the different avian species, in those which are supposed to belong to older natural orders in the evolutionary scale[4,5], namely, the chicken, pigeon, etc., the kidney tissue and not liver could synthesize ascorbic acid. However, in the majority of the species studied belonging to the Passeriformes, a more recent natural order, the liver tissue and not the kidney tissue could synthesize ascorbic acid. In two species belonging to this natural order, namely, the house crow and the common myna, both the liver and kidney tissues could effect this synthesis, the liver being more active than the kidney. But in one species —the red-vented bulbul—belonging to this natural order, neither the liver nor the kidney could bring about the synthesis. It would thus appear that in the natural orders in the earlier stages of evolution, namely, the amphibians and the reptiles, the biosynthetic mechanism for ascorbic acid resides in the kidney tissue. It continues to be so in the different species of birds until in the most recent natural order, the Passeriformes, the liver takes over this function, a few species sharing it with the kidney in a smaller degree and one having both liver and kidney tissues incapable of effecting this synthesis. Thus in the evolutionary ascent this mechanism seems to pass from the kidney to the liver and then to disappear also from the liver.

This is in agreement with the observation that the liver tissues of all lower mammals studied except the guinea pig can synthesize ascorbic acid, but this capacity of the liver is absent in the more evolved primates. Thus in the case of the rat the liver but not the kidney can synthesize ascorbic acid. The case of the flying mammal, the Indian fruit bat, is interesting. We had expected its liver tissue, in common with that of most mammals, to be able to synthesize ascorbic acid, but neither its liver nor its kidney could do so. The bat is supposed to be closely related to the primates, which are known to be unable to synthesize ascorbic acid, and this may be further biochemical evidence for the relationship. These results indicate that although practically all species except the primates and the guinea pig are supposed to be able to synthesize ascorbic acid, it is possible that several of them cannot do so, and the cyanide technique might provide a simple means for determining this capacity.

It may be mentioned that in all these cases, the biosynthesis of ascorbic acid has been found to be inhibited by *p*-chloromercuribenzoate, this effect being reversed by reduced glutathione. This had already been observed with the liver tissue of the rat and goat[2]. It suggests that thiol groups are involved in the enzyme systems concerned, whether they are in the liver or in the kidney tissue. The fact that the enzyme systems of the liver and of the kidney of all species studied operate in the same way with respect to the effect of cyanide, specificity of substrate, effect of *p*-chloromercuribenzoate, etc., indicates that the enzyme systems concerned are identical or closely similar, whatever the species.

We wish to thank Dr. B. Biswas, Zoological Survey of India, and Prof. J. L. Bhaduri, head of the Department of Zoology, University of Calcutta, for their advice and assistance with the identification of the species and the Indian Council of Medical Research for a research grant.

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Hæmoglobin and Potassium Blood Types in Some Non-British Breeds of Sheep and in Certain Rare British Breeds

Sheep may be classified into three types, *A*, *B* or *AB*, according to whether they possess one, or another, or a mixture of two distinct hæmoglobins[1–3]. They may also be classified quite independently into two types, *HK* and *LK*, according to whether the concentration of potassium in their whole blood is relatively high or low[4]. Both sets of characters are determined genetically and the genes responsible are at different chromosomal loci[3,5].

In an extensive survey of more than thirty different British breeds of sheep we have been able to show that the majority of these breeds are polymorphic with respect to the genes at both these loci, but that large differences in gene frequency occur from breed to breed[6]. The mountain and hill breeds, particularly those from the northern part of Britain, tend to have rather high frequencies of hæmoglobin *A* and *HK*, while the lowland breeds tend to have high frequencies of hæmoglobin *B* and *LK*. A detailed map of the distribution of these characters in breeds of sheep from other countries would be of obvious help in attempting to assess the biological significance of this kind of polymorphism.

During the past three years we have had the opportunity of examining the hæmoglobin and blood potassium types in a number of breeds of sheep located in widely scattered parts of the world. The data are in many respects incomplete and fragmentary, and the number of animals tested is relatively few. Nevertheless, it seems worth while recording the results at this stage because they do give a rough indication of the frequencies of these characters in sheep from very diverse places, and they may be useful to workers in other countries examining these characters in their local breeds.

Heparinized blood samples were sent by air to England from the various points of collection, and the time taken in transit varied from about three days for the Awasi (Israel) to about twenty-one days for the Merino samples from the Northern Territory of Australia. A proportion of the samples could not be used for hæmoglobin typing because of gross hæmolysis, and occasionally clotting had occurred and this prevented a satisfactory determination of the potassium content of the whole blood. We have, however, no reason to believe that one or another of the blood types were selectively affected in this way.

Table 1. Hæmoglobin and Potassium Blood Types in Fourteen Non-British Breeds of Sheep

Breed	Sample obtained from	Believed place of origin of breed (cf. ref. 11)	Hæmoglobin types					Blood potassium types		
			No. tested	*A*	*AB*	*B*	Estimated frequency of *A* gene	No. tested	*LK*	Frequency of *LK* type
Scandinavian:										
Finnish	Finland	Finland	26	26	0	0	1·0	42	15	0·36
Icelandic	Iceland	Iceland	44	29	14	1	0·82	44	2	0·05
Old Norwegian	Norway	Norway	9	9	0	0	1·0	44	5	0·11
African/Middle East:										
Awasi	Israel	Syria, Israel and Iraq	39	0	0	39	0·0	59	15	0·25
Awasi	Iraq		47	1	3	43	0·05	48	4	0·08
Barki	Egypt	North-West Egypt	37	1	7	29	0·12	42	34	0·81
Blackheaded Persian	Tanganyika	South Africa	21	0	0	21	0·0	46	5	0·11
Fulani	Nigeria	Senegal to Cameroons	60	2	3	55	0·06	69	16	0·23
Masai	Tanganyika	Tanganyika, Kenya, Uganda	30	0	0	30	0·0	42	8	0·19
Rahmani	Egypt	Lower Egypt	43	0	1	42	0·01	43	7	0·16
Merino:										
Northern Territory, Australia	Australia	Spain	37	3	22	12	0·38	39	39	1·00
Rambouillet	France		19	11	8	0	0·79	23	23	1·00
Tasmania	Australia		24	7	14	3	0·58	25	23	0·92
Others:										
Bighorn	Canada (Alberta)	Rocky Mountains (North America)	4	0	0	4	0·0	4	0	0·00

The results are given in Table 1. The distribution of the hæmoglobin types in the Scandinavian breeds contrasts strikingly with that found in the Middle Eastern and African breeds. In the former, hæmoglobin *A* is very common, while in the latter, hæmoglobin *B* preponderates. On the other hand, *LK* is relatively infrequent both in Scandinavia and in the Middle East and Africa (with the single exception of the Barki), and it is clear that the correlation in gene frequencies between *B* and *LK* which occurs in British breeds does not apply here.

The Merinos form a distinctive and peculiar group. The three flocks studied were almost entirely *LK*, a fact which agrees with earlier reports[7,8], but both types of hæmoglobin are fairly common.

The interpretation of the results for *HK* requires special comment. It is thought probable that four types of sheep may occur, with distinctive concentrations of potassium and sodium in the red cells. These have been called[9] *Keα*, *Keβ*, *Keγ* and *KeΔ*. On whole-blood analysis *Keβ*, γ and Δ fall into the *HK* group and *Keα* into the *LK* group. The distinction between *Keβ*, γ and Δ requires determinations of the concentrations of potassium and sodium in the red blood cells using fresh blood. In practice, whole-blood determinations are adequate in most surveys of British breeds of sheep because it has been found that *Keβ* and *KeΔ* are extremely rare in Britain and, therefore, *HK* almost invariably implies *Keγ*. In the Middle East and Africa this is probably not the case, and it is possible that *Keβ* and *KeΔ* may be quite common. In Kerr's data[10] from Lebanese fat-tailed sheep, for example, *KeΔ* was the most common type although all four types were demonstrated. In the present survey the potassium content of the whole blood in the *HK* group was on the average appreciably lower in the Middle Eastern and African breeds than in the Scandinavian breeds and one possible explanation of this is that *Keβ* and Δ types may have been present in the former but not in the latter. Such differences can, however, only be ascertained by detailed studies using fresh blood samples.

Table 2. Hæmoglobin and Potassium Types in Breeds of Sheep in the Zoological Gardens, London

Breed	Believed place of origin of breed	No. tested	Hæmoglobin types			Potassium types	
			A	*AB*	*B*	*HK*	*LK*
Mouflon	Corsica and Sardinia	4	2	2	0	2	2
Barbary	Libya, Tunisia and E. Algeria	5	0	0	5	2	3
Jacob's (Spanish Piebald)	? Spain ? Hebrides	7	0	6	1	0	7
Manx	Isle of Man	4	0	0	4	4	0
Soay	Hebrides	12	1	0	11	11	1
Old Norfolk Horn	England	7	0	0	7	7	0

It is appropriate also to report here the results we have obtained from testing a small number of sheep at present in the Zoological Gardens, London (Table 2). They include certain rather rare breeds. In fact, the seven examples of the Old Norfolk Horn are probably the only remaining members of this once quite numerous breed. It is notable that in spite of the small numbers involved, four out of the six breeds examined were polymorphic with respect to one or other of the two sets of characters. A further point of interest is that in the Barbary sheep it was possible to carry out determinations of the potassium and sodium in the red blood cells, and the two *HK* animals were found to be *Keβ*.

A grant from the Agricultural Research Council to one of us (F. L. W.) has supported this work. We are also indebted to overseas colleagues and the Zoological Society of London for blood samples.

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Hæmoglobin *P* (the 'Galveston' Type)

An earlier communication[1] described a new variant of human hæmoglobin tentatively called the 'Galveston type'. This variant appears identical with hæmoglobin *L*[2] in paper electrophoresis, veronal buffer, *p*H 8·6, 0·05 *M*, but differs from similar types in that it does not separate from hæmoglobin *A* in free electrophoresis, cacodylate buffer, *p*H 6·2–6·9, 0·1 *M*. It is now suggested that this variant (found in a Negro woman, 'MTu', and in one of her two children) be called hæmoglobin *P*. Fig. 1 shows a photograph of the paper electrophoresis pattern of 'MTu's' hæmoglobin sample, compared with those from subjects with sickle cell trait, hæmoglobin *G* trait, and hæmoglobin *Q* trait. (The sample of hæmoglobin *G* trait[3] is from the subject 'AK'; that of hæmoglobin *Q* trait[4] was kindly supplied by Dr. H. Lehmann.) The various types of hæmoglobin in these samples, listed in order of decreasing mobility, are as follows: *A*, *Q*, *G*, *P* and *S*.

In other types of zone electrophoresis (starch block and agar, both in veronal buffer) 'MTu's' hæmoglobin sample is again resolved into two components, similar to those on paper. Quantitative estimation of these was obtained from the starch-block electrophoresis by determining the concentration of the eluted components spectrophotometrically; the proportions were found to be approximately 1 : 1. However, in

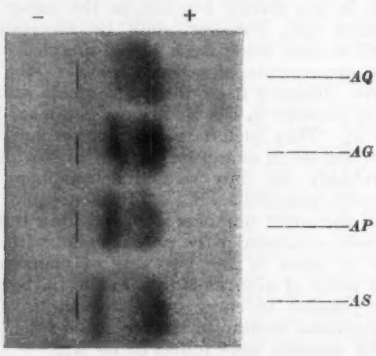

Fig. 1. Paper electrophoresis patterns of hæmoglobin samples *AQ*, *AG*, *AP* and *AS*. Veronal buffer, *p*H 8·6, 0·05 *M*

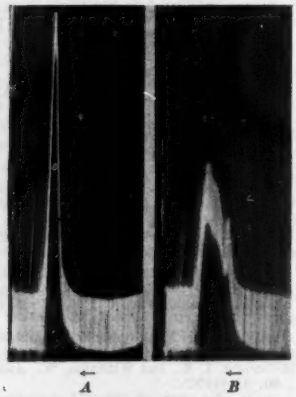

Fig. 2. Scanning diagrams of ascending patterns of 1 : 1 mixtures of 1 per cent carboxyhæmoglobin samples, cacodylate buffer, *p*H 6·5, 0·1 *M*. *A*, 'MTu's' (*AP*) with hæmoglobin *A*; *B*, 'MTu's' (*AP*) with 'AK's' (*AG*)

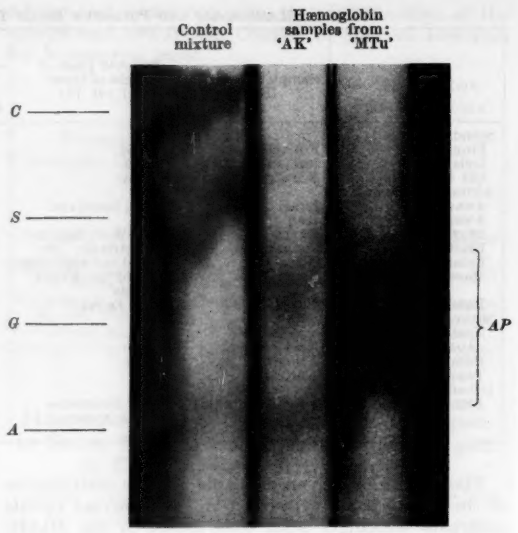

Fig. 3. Chromatography of carboxyhæmoglobin *AP* on columns of 'Amberlite' resin

the recently developed citrate agar method[5], 'MTu's' hæmoglobin sample was again indistinguishable from hæmoglobin *A*.

It has already been noted that in free electrophoresis, cacodylate buffer, *p*H 6·5, μ 0·1, hæmoglobin *AP* migrates as one sharp peak. This was also the case in an analysis with this same buffer of a 1 : 1 mixture of 'MTu's' hæmoglobin sample and hæmoglobin *A* (Fig. 2*A*). Similarly, in free electrophoresis in phosphate buffer, *p*H 6·4, 0·04 *M* [6], the hæmoglobin *AP* of 'MTu's' sample migrates as one sharp peak. The similarity of results with these two different buffers would seem to indicate that in this *p*H range the net charge of hæmoglobin *P* is identical with that of hæmoglobin *A*. However, a lack of true identity is suggested by the fact that in free electrophoresis in cacodylate buffer, mixtures of 'MTu's' hæmoglobin sample with those containing hæmoglobin *S* or *G* develop into two peaks of variable and unpredictable proportions[1], unlike mixtures of *A* and *S* or *G*, which are resolved quantitatively; even more striking is the fact that mixtures of 'MTu's' sample with those containing hæmoglobin *AG* (from patient 'AK') were, on several occasions, resolved into a pattern suggesting the presence of three components (Fig. 2*B*),

Another method of comparing the net charge of various types of hæmoglobin in an acid buffer[7] is that of chromatography on columns of 'Amberlite' resin[8]. In this method hæmoglobin *P* is not sharply differentiated from hæmoglobin *A*, but the diffuse band produced by *AP* in comparison with that produced by *A* suggests again that these two types are not quite identical with respect to net charge in acid buffer (Fig. 3).

In free electrophoresis in an alkaline buffer (veronal, *p*H 8·6, 0·1 *M*), no clear separation was obtained between the *A* and the *P* of 'MTu's' hæmoglobin sample, but the asymmetry of the peak strongly suggested electrophoretic heterogeneity[1]. (In these circumstances the peak produced by *AG* appears relatively symmetrical[9]. This suggests that in free

electrophoresis, veronal buffer, as in zone electrophoresis, the mobility of *P* is slightly less than that of *G*.) In an attempt to sharpen this heterogeneity, an aliquot of hæmoglobin *A* was added to an equal amount of 'MTu's' hæmoglobin sample, and the mixture was analysed in free electrophoresis, veronal buffer, *p*H 8·6, 0·1 *M*. It was then resolved into two distinct peaks in both the ascending and descending patterns, and the areas of these peaks were in about the expected proportions (3*A* : 1*P*).

Hæmoglobin *P* may now be characterized as follows: in zone electrophoresis, veronal buffer, *p*H 8·6, the mobility of *P* lies between *G* and *S*, like that of hæmoglobin *L*[2]. In free electrophoresis in acid buffer (cacodylate *p*H 6·2–6·9, 0·1 *M* or phosphate, *p*H 6·4, 0·04 *M*) the mobility of *P* appears identical with that of *A*. However, in analyses of mixtures of *P*, *A* and *G* (cacodylate *p*H 6·5), there is indication that in this *p*H range the net charge of *P* is not precisely the same as that of *A*, but rather that *P* overlaps *A* and *G* in this respect. This is also suggested by the results of column chromatography with 'Amberlite', citrate buffer, *p*H 6·5 (ref. 8). In free electrophoresis in alkaline buffer (veronal, *p*H 8·6, 0·1 *M*) *P* does not separate clearly from *A* in a 1 : 1 mixture of these two types. However, in a mixture containing approximately three parts of *A* and one part of *P*, quantitative separation does occur, and the mobility of *P* (as in zone electrophoresis) is less than that of *A*. Finally, in free electrophoresis at *p*H 6·5 of mixtures of *P* with other types of hæmoglobin, the qualitative and quantitative resolutions of *P* are to a unique extent influenced by the nature of the companion proteins.

This work was aided by U.S. Public Health Service Grant *A*–780.

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Gamma-Amino-*n*-Butyric Acid and Spinal Synaptic Transmission

A MAJOR constituent of factor I isolated from mammalian brain has been shown to be γ-amino-*n*-butyric acid[1]. It has been assumed that this material, an inhibitor of the crayfish stretch receptor, is an inhibitory transmitter substance within the mammalian central nervous system[2]. Recent investigations indeed have shown that γ-amino-*n*-butyric acid reversibly depresses the potentials arising from the synaptic activation of cells within the cerebral cortex[3] but no precise differentiation as to the mode of action of γ-amino-*n*-butyric acid has been attempted.

In the present investigation, γ-amino-*n*-butyric acid has been passed electrophoretically, as a cation, from one barrel of a multi-barrelled electrode. The responses, both of single cells and of groups of cells within the spinal cord of the cat, have been recorded from another barrel of the electrode filled with 4 *M* sodium chloride solution.

In the dorsal horn and intermediate nucleus of the spinal cord, cells caused to discharge by volleys in skin or muscle afferent fibres are prevented from firing by γ-amino-*n*-butyric acid. Similarly in the ventral horn, motoneurones cannot be fired either orthodromically or antidromically under the influence of γ-amino-*n*-butyric acid. In addition, the antidromic responses of small motoneurones, and the responses of Renshaw cells both to synaptic stimulation and activation by ionophoretically applied acetylcholine, are prevented by γ-amino-*n*-butyric acid. All these effects of the acid are evoked by currents of 20–350 × 10^{-9} amp. and are of short latency and rapidly reversible.

In both the dorsal and ventral horns focal synaptic potentials, recorded extracellularly and evoked by simultaneous excitation or inhibition of groups of cells, are diminished or even abolished by γ-amino-*n*-butyric acid. This reduction of excitatory focal synaptic potentials is not altered by strychnine administered intravenously, and is not accompanied by any diminution in the size of potentials recorded simultaneously from the pre-synaptic fibres. Excitatory synaptic potentials, evoked in motoneurones by impulses in group *Ia* afferent fibres, and recorded extracellularly as negative potentials, could be converted into positive potentials, indicating that the membrane behaving as a sink for current had been converted into a source.

These results make it extremely unlikely that γ-amino-*n*-butyric acid is a transmitter substance in the mammalian spinal cord. In particular, the abolition of the excitatory post-synaptic potentials of motoneurones recorded extracellularly excludes the possibility that γ-amino-*n*-butyric acid is the inhibitory transmitter upon these cells. Although it might be expected that excess inhibitory transmitter would lead to hyperpolarization of the cell with abolition of inhibitory post-synaptic potentials, the actual alteration in the membrane conductance would be small[4]. Hence, post-synaptic excitatory potentials would not be abolished and focal synaptic potentials, consisting predominantly of extracellularly recorded excitatory potentials, would still be recorded.

Accordingly, it is probable that γ-amino-*n*-butyric acid has a depressant action on the whole somadendritic membrane of centrally located neurones, both the chemically activated subsynaptic membrane and the remaining electrically activated post-synaptic membrane.

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Self-depression of the Subcutaneous Absorption of Drugs due to Release of Histamine

In experiments on the subcutaneous absorption of drugs from injected solutions we have demonstrated a marked self-depression of the subcutaneous absorption, due to histamine released by the injection trauma.

The absorption experiments were carried out by injecting 2 ml./kgm. of an aqueous sulphacetamide sodium solution (50 mgm./ml.) subcutaneously to rabbits and rats, and then determining the concentration of sulphacetamide in the serum at different times after the injection[1,2]. Both in rabbits (Fig. 1) and in rats (Table 1) the concentrations in serum, compared with control experiments, were markedly lowered for the first 20 min. after the injection, when histamine hydrochloride (90 μgm./ml.) was added to the injection fluid. Histamine dilates capillaries and enhances their permeability. Therefore, delayed absorption is possibly due to the preponderance of the transcapillary filtration during the formation of the œdema provoked by histamine.

Table 1. Concentration of Sulphacetamide in Serum (μgm./ml.) from Rats, 5 min. after Subcutaneous injection of 2 ml./kgm. of a Sulphacetamide Sodium Solution (50 mgm./ml.)

Pre-treatment	No. of experiments	Mean	Standard error of mean	*P*
Controls	16	53·6	± 2·5	
Histamine locally	9	38·3	± 4·5	< 0·001
Histamine depleted	10	71·4	± 3·1	< 0·001
Mepyramine	8	77·7	± 2·5	< 0·001

In experiments on rats, where the concentration of sulphacetamide was determined in serum 5 min. after the subcutaneous injections, depletion of the tissue histamine content and blocking the sensitivity to histamine by mepyramine maleate gave a pronounced and statistically significant rise in the concentrations measured, when compared with the results from experiments on untreated animals (Table 1). The difference amounted to about 30 per cent. The histamine depletion was brought about with compound 48/80, giving 0·25, 0·50, 0, 1·0, 1·0, 0, 1·5, 2·0 and 2·5 mgm./kgm. intraperitoneally in a 1/2,000 solution in saline (8·5 mgm./ml.) on the first to the tenth day. Absorption experiments were performed on the eleventh day. 50 mgm./kgm. mepyramine maleate (25 mgm./ml. in saline, 8·5 mgm./ml.) was given in a single dose intraperitoneally 45 min. before the absorption experiments.

The results mentioned above have been confirmed in absorption experiments on rats with subcutaneous injection of 5 ml./kgm. morphine hydrochloride (20 mgm./ml.) solution, in collaboration with Kirsten Milthers, using a method for the determination of small quantities of morphine in blood, developed by Milthers[3]. Morphine is known to be a chemical histamine liberator. Therefore a marked self-depression of the subcutaneous absorption of morphine was expected. This view was confirmed by the experimental results. The concentration of morphine in the blood 10 min. after a subcutaneous injection is 100 per cent higher in rats depleted of histamine or treated with mepyramine (7·5–10 μgm./ml.) than in untreated control animals (about 4 μgm./ml.).

From the experimental results, I suggest that the subcutaneous absorption of drugs is normally reduced for the first 20 min. after the subcutaneous injection

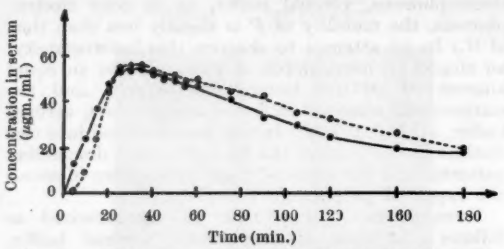

Fig. 1. Mean curves showing the concentration in serum (μgm./ml.) from three cross-over absorption experiments on rabbits given 2 ml./kgm. sulphacetamide sodium (50 mgm./ml.) subcutaneously on the abdomen. ●——●, Controls; ○- - - ○, experiments with histamine hydrochloride (90 μgm./ml.) added to the injection solution

due to a self-depression caused by release of tissue (mast-cell) histamine. When the injected drug is a chemical histamine liberator, such as morphine, the self-depression is very pronounced. When the injected drug is without chemical histamine-releasing activity, only the injection trauma and the injection of a non-physiological fluid (which a drug solution is) provoke a lesser liberation of histamine, giving a smaller, but qualitatively similar, self-depression of the absorption-rate.

I am grateful to Prof. Knud O. Møller, for his interest in this work, and to Dr. A. C. Withe, of the Wellcome Research Laboratories, for a sample of compound 48/80.

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Level of Liver Glycogen in Ketosis

Since von Mering and Minkowski[1] showed that the liver of the depancreatized dog contains little glycogen, it has been widely held that the degree of ketosis is inversely proportional to the level of liver glycogen. Thus Mirsky[2] believes that ketogenesis in diabetes mellitus arises either as a result of glycogenolysis or when the liver glycogen has fallen to a critical level. Burn and Ling[3] have shown that the same relationship holds for the normal rat on a high fat diet. However, evidence is accumulating which shows that this inverse relation is by no means invariable. Appreciable quantities of hepatic glycogen have been found in severely diabetic subjects[4], and in ketotic rats after alloxan administration[5]. It has been shown in this laboratory that in the intact normal rat it is possible to obtain a very high ketonæmia concomitant with high levels of liver glycogen.

Female rats were fasted for 24 hr. to reduce the liver glycogen to minimal levels and then placed on a diet of filtered butter fat (plus 3 per cent salts). 7 gm. of the diet were fed to each rat daily, the portion not consumed voluntarily being administered by stomach tube. The course of the ensuing ketonæmia and ketonuria (Fig. 1) was followed by the method of Mayes and Robson[6]. After 7 days the rats were killed by cervical fracture and the left lateral lobe of the liver assayed for glycogen. Fat was estimated in the remainder of the liver by extraction with ether. Since the glycogen- and fat-levels of the

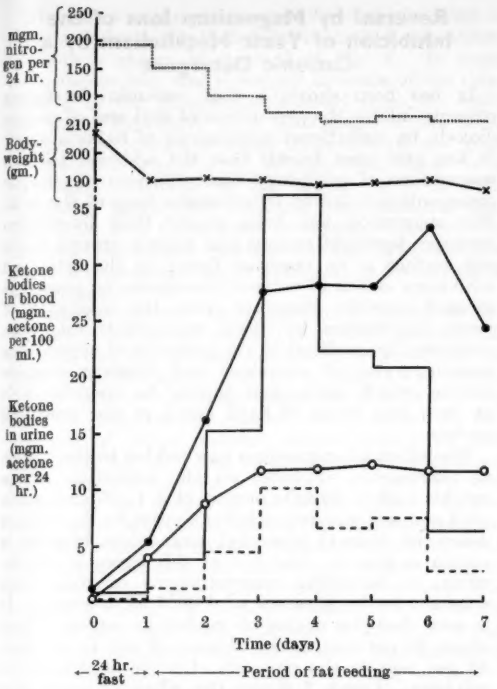

Fig. 1. The course of ketosis in rats (mean of three) starved for 24 hr., then fed 7 gm. per day of butter fat. ●, β-Hydroxybutyric acid in blood; ○, acetone plus acetoacetic acid in blood; ——, β-hydroxybutyric acid in urine; — — —, acetone plus acetoacetic acid in urine; ×, body-weight; ····, total nitrogen in urine

liver fluctuate widely under varying conditions, they are expressed in terms of the glycogen-free, fat-free dry liver weight. The experiments were carried out during the month of May.

Fig. 1 shows that the ketonæmia rose rapidly and after the third day remained at a high level. The ketonuria reached a maximum and thereafter subsided considerably. Seemingly, the apparent renal threshold for ketone bodies changed during the course of the experiment. The individual values at death for liver glycogen and fat are shown in comparison, with the corresponding ketonæmic levels (Table 1). Normal or appreciable quantities of liver glycogen were found to co-exist with a high ketonæmia. Moreover, the liver fat was substantially elevated, thereby demonstrating the lack of any mutual exclusion effect with glycogen. Increased gluconeogenesis from protein was not responsible for the accumulation of glycogen in the liver, as the levels of total urinary nitrogen remained depressed.

Table 1. Levels of Ketonæmia, Liver Glycogen and Liver Fat in Rats starved for 24 hr. then fed 7 gm. per day of Butter Fat for Six Days

	Total ketone bodies in blood (mgm. acetone/ 100 ml.)	Liver glycogen		Liver fat	
		Total (mgm.)	gm./100 gm. of glycogen and fat-free dry weight	Total (mgm.)	gm./100 gm. of glycogen and fat-free dry weight
Rat 1	16·44	279	23·1	1,200	99·2
Rat 2	40·82	139	10·8	885	68·6
Rat 3	50·00	190	14·7	1,023	79·0
Normal fed controls (3)	1·63*	335	21·4	146	9·42

* Mean initial level of experimental rats fed butter fat.

The general and undisputed occurrence of ketosis when the liver glycogen-level is low provides the best evidence for an inverse relation. The finding of ketosis in the presence of high concentrations of liver glycogen need not necessarily invalidate this concept. The present results may be interpreted as indicating that in the normal animal a non-glycogenolytic ketogenic factor (or factors) is able to operate, the effect of which is superimposed on the inverse relation between the level of liver glycogen and the degree of ketosis. It is noteworthy that Houssay[7], and others, have described hormonal preparations of the anterior pituitary gland which possess these properties. Such a mechanism could account adequately for the variations in severity of ketosis in diabetic and non-diabetic animals which cannot be explained by the level of liver glycogen alone.

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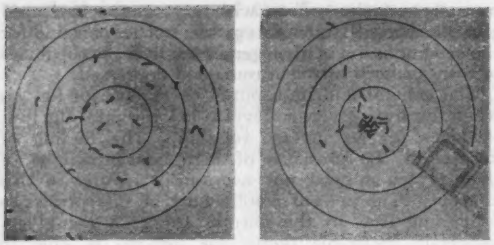
Substances in Mulberry Leaves which attract Silkworm Larvæ (*Bombyx mori*)

Although the larvæ of silkworms eat a few kinds of leaves other than mulberry leaves, for example, fig and lettuce, these do not support normal growth. Proteins and carbohydrates are necessary food substances, but are incapable of acting as attractants, since they are odourless. Experiments showed that mulberry leaves placed within 3–4 cm. of silkworm larvæ did attract them. An investigation was carried out on thirty-eight species of leaves as to the chemotaxis of silkworm larvæ[1]. It was found that substances which attract silkworm larvæ exist widely in green plants, but that the degree of attractivity differs. The leaves of soya bean, mulberry and tea had the strongest attractivity, but the silkworm larvæ gathered around them without eating them. On the other hand, silkworms exhibited a weak chemotaxis to the leaves of fig and lettuce, but ate them when hungry.

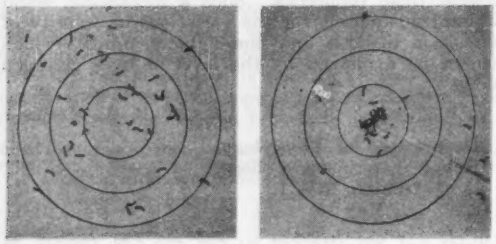
Commercially available organic acids, aldehydes, alcohols and ketones, which are present in green plants, were investigated as to the chemotaxis of silkworm larvæ, but had little effect[1]. *iso*Valeraldehyde, which is known to attract flies[2], hexyl alcohol and *iso*amyl alcohol were slightly positive.

Volatile substances were separated from mulberry leaves by steam distillation. Approximately twenty types of compound were identified as derivatives: alcohols as 3,5-dinitrobenzoates; aldehydes and ketones as 2,4-dinitrophenylhydrazones; and acids as *p*-phenyl phenacyl esters[3–6].



No attractant — Attractant—neutral fraction (b.p. 120–170° C.)

Fig. 1. Attractivity of the essential oil from mulberry leaves for the silkworm larvæ



No attractant — Attractant—β-γ-hexenol

Fig. 2. Attractivity of β-γ-hexenol

The neutral fraction from the essential oil of mulberry leaves, especially that with b.p. 120–170° C., attracted silkworms[1]. *n*-Butanol and β-γ-hexenol were detected as alcohols[5], and *n*-butyraldehyde, *iso*butylaldehyde, *n*-valeraldehyde, α-β-hexenal and methyl-ethyl ketone as aldehydes and ketones in this fraction[3,4]. All the compounds other than β-γ-hexenol and α-β-hexenal had already been tested as to their effects on the chemotaxis of silkworm larvæ.

β-γ-Hexenol and α-β-hexenal could not be obtained in the free state from mulberry leaves. These compounds were obtained from the essential oil of *Mentha rotundifolia* L. according to the method of Takei[7]. β-γ-Hexenol attracted the silkworm larvæ strongly. α-β-Hexenal, made by oxidation of β-γ-hexenol, also showed attractivity.

From these experiments it was concluded that the compounds in mulberry leaves which attracted the silkworm were β-γ-hexenol and α-β-hexenal. The larvæ when young tend to be attracted to β-γ-hexenol, and to α-β-hexenal when older.

I am much indebted to Prof. G. S. Fraenkel for helpful discussion.

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Reversal by Magnesium Ions of the Inhibition of Yeast Metabolism by a Cationic Detergent

It has been shown[1,2] that cationic detergents strongly inhibit the production of acid and of carbon dioxide by unbuffered suspensions of baker's yeast. It has also been found[2] that the addition to such suspensions of inhibitory concentrations of cationic detergents is followed by extensive lysis of the cells. The suggestion has been made[2] that interaction between detergent cations and anionic groups in the cell surface is an essential factor in the lytic and inhibitory action of cationic detergents on yeast. It seemed possible, therefore, that the inhibition of yeast metabolism by these compounds might be considerably modified in the presence of appropriate concentrations of univalent and bivalent metallic cations which have been shown[3] to combine with at least two types of fixed anion in the yeast cell surface.

The effect of magnesium ions (added to the system as magnesium sulphate) on the inhibition of the aerobic carbon dioxide output of a 1 : 20 suspension (in 5 per cent glucose) of baker's yeast by the cationic detergent dodecyl trimethyl ammonium bromide is shown in Fig. 1. Curve 1 of this figure shows the effect of increasing concentrations of magnesium sulphate in the presence of 0·0025 *M* detergent. It is seen that the degree of inhibition decreases from about 93 per cent in the absence of salt to less than 40 per cent in the presence of 0·004 *M* magnesium sulphate. Curve 2 shows the effect of magnesium sulphate, over the same concentration range, on the inhibitory action of a slightly smaller concentration of detergent (0·002 *M*). In this case the degree of inhibition was reduced from some 85 per cent in the absence of salt to about 10 per cent in the presence of 0·004 *M* magnesium sulphate.

It appears that this effect is observed only when the salt is added to the suspension before or at the same time as the detergent. It is seen from Fig. 1 (curve 4) that the addition of magnesium sulphate (up to 0·003 *M*) to yeast suspensions which had been exposed, for 30 min., to 0·0025 *M* dodecyl trimethyl ammonium bromide did not result in any observable increase in fermentative activity.

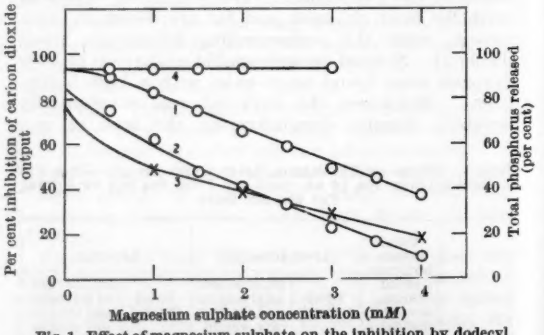

Fig. 1. Effect of magnesium sulphate on the inhibition by dodecyl trimethyl ammonium bromide of the aerobic production of carbon dioxide by baker's yeast (curves 1, 2 and 4). Yeast suspension; 1 part by weight in 20 vol. suspension fluid containing 5 per cent glucose. Detergent concentrations; 0·0025 *M* (curves 1 and 4) and 0·002 *M* (curve 2). Curves 1 and 2, detergent and salt added simultaneously to suspension. Curve 4, detergent added 30 min. before salt. Curve 3, effect of magnesium sulphate on the release of total phosphorus (expressed as a percentage of the amount extracted from the cells by 10 per cent trichloracetic acid) from yeast cells by dodecyl trimethyl ammonium bromide. Yeast suspension, 1 : 20 without glucose

The effect of magnesium sulphate on the lysis of yeast cells by 0·002 *M* dodecyl trimethyl ammonium bromide is shown in curve 3 of Fig. 1. In these experiments lysis was measured in terms of the total amount of the phosphorus released from the cells, this being expressed as a percentage of the total phosphorus extracted from them by 10 per cent trichloracetic acid[2,4,5]. It is seen that there is a progressive decrease in the degree of lysis with increasing magnesium sulphate concentration and that there is a fairly close correlation between the effect of magnesium sulphate on the lytic activity of the detergent and on its inhibitory action on yeast metabolism.

That the reversal, by magnesium sulphate, of the inhibitory action of dodecyl trimethyl ammonium bromide on the aerobic carbon dioxide output of yeast described above may be ascribed to an effect, on the cells, of the magnesium ion is indicated by the fact that similar results are obtained in the presence of other metallic cations which do not themselves inhibit yeast metabolism, and that these results do not appear to depend, to any marked extent, on the nature of the added anion. In the case of salts of bivalent metals (for example, calcium chloride, strontium nitrate, barium chloride, ferrous sulphate, cobalt chloride) the results obtained indicate that the ability of bivalent cations to reverse the inhibitory action of dodecyl trimethyl ammonium bromide on yeast metabolism is, in general, of the same order as that of magnesium ions. The univalent ions tested (lithium, sodium, potassium and ammonium) appeared to be considerably less effective than magnesium ions while the trivalent lanthanum ion showed markedly greater activity than magnesium.

I consider that these results may be interpreted as indicating that magnesium and other metallic cations can, under appropriate conditions, compete with dodecyl trimethyl ammonium bromide for fixed anionic sites on the yeast cell surface.

These experiments were carried out during the tenure of a fellowship of the Medical Research Council of Ireland at the Department of Physiology, University College, Dublin. They will be published in detail elsewhere.

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Survival of Intact Insects immersed in Liquid Oxygen without any Antifreeze Agent

It is well known that various organisms can be cooled to very low temperatures in liquid gases without injury, provided that they have previously been desiccated to some extent. Extracellular freezing is considered to be a mode of dehydrating living cells; and some organisms, at least frost-resistant ones, may withstand freezing of this type even at very low temperatures. On the other hand, many living organisms survive slow cooling to extremely low temperatures[1]. This might also be explained by dehydration due to extracellular freezing. In these cases, however, the materials used were usually isolated cells or very small pieces of tissue. The largest entire animal hitherto found to survive freezing at a very low temperature is the tiny vinegar eel[2]. Our experiments show that, after sufficient extracellular freezing, an intact insect can be kept alive at an extremely low temperature without any antifreeze agent.

We used a 'slug caterpillar', *Cnidocampa flavescens* (Walk.) in the overwintering prepupal stage, when these insects form hard cocoons in which they complete their metamorphosis in the succeeding summer. The naked prepupal larvæ from the cocoons usually range from 250 to 450 mgm. in weight; they are very resistant to intense cold as well as to prolonged body freezing[3]. The freezing process of the larva is probably as follows[4]. At first, when cooled below about − 20° C., the blood freezes rapidly and then extracellular freezing of the tissue cells occurs. The tissue cells undergo dehydration and contraction; nevertheless they usually withstand such severe conditions for a long period, provided the rate of cooling is not too great.

In our experiments the larvæ in their cocoons were first frozen in a special refrigerator, in which the air temperature was lowered from − 5° to − 90° C. in 1½ hr. and maintained at that temperature for 45 min. The insects were then rewarmed in air at room temperature. After thawing, about one-third of the sixty larvæ revived.

This result suggested that, after partial dehydration due to extracellular freezing, the insect might survive even rapid cooling to a very low temperature, and encouraged us to try freezing the same animal in liquid oxygen after preliminary freezing at graded temperatures.

100 insects were divided into five groups, each of ten larvæ in intact cocoons and an equal number from which the cocoons had been removed. The first group was stored at 0° C. The second was kept for one day at − 10° C., at which temperature the insect never freezes spontaneously[3]. The third was also kept at − 10° C. for one day after the larvæ had been subjected to freezing at − 20° C. The fourth and the fifth groups were held for one day at − 20° C. and − 30° C. respectively, at which temperatures the larva usually freezes within 40 min. All five groups of insects were then immersed directly in liquid oxygen. After being kept there for a full day, they were held in air at − 30° C. for 4 hr. and then transferred into air at room temperature. Among the five groups, revival of the insects after thawing occurred only in the last. Of ten naked larvæ, nine recovered the active movement of the heart which was easily visible through the dorsum. None of them, however, pupated even after incubation at 20° C. for fifty days, nor did the larvæ in intact cocoons, at least within fifty days of incubation. Control insects, stored at 0° C. and then incubated at 20° C., usually completed metamorphosis within fifty days.

A preliminary experiment showed that the tissue cells of this larva are not affected by freezing for several days at − 40° C., provided that the ice formed is extracellular. In the larvæ of the fifth group, most of the tissue cells appeared to be quite normal immediately after thawing except for the fat

cells, in which the small fat granules of uniform size sometimes fused into larger homogeneous masses. In the larvæ of all the other groups a remarkable destruction of the fat body usually took place, and when the insect body was dissected numerous small oil droplets, which had flowed out from the fat cells, were observed on the blood surface. In this case some of the tissue cells probably froze intracellularly, whereas in the fifth group most of the cells must have frozen extracellularly. It is therefore reasonable to suppose that if the insects are previously frozen extracellularly at − 30° C., scarcely any water crystallizes in the tissue cells even at an extremely low temperature.

Similar results were obtained from experiments on the overwintering larva of a butterfly, *Aporia crataegi adherbal* Fruhstorfer. The body-weight of this larva was about 1·7 mgm. Two groups of about fifty larvæ in the hibernacula were frozen at − 20° C. and − 30° C. respectively for one day and then immersed directly in liquid oxygen for a full day. After thawing in air at room temperature, all the larvæ prefrozen at −20° C. were found to have been killed, whereas most of the larvæ prefrozen at − 30° C. recovered their motility and have been growing normally on the leaf of apple, the food plant.

Further details of this work will be published elsewhere.

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Ultra-structure of the Coxal Glands of the Scorpion

Although much is known, nowadays, about submicroscopic structures of the vertebrate kidney, we still have very poor information on the ultra-structure of invertebrate excretory organs.

Beams *et al.*[1] have studied the cells of grasshopper Malpighian tubules with the electron microscope. They also referred to unpublished evidence concerning the 'nephron' tubule cells of the crayfish. In both cases it appears that some particular features are common to these excretory cells and to vertebrate nephron cells. The most characteristic of these features is the great amount of mitochondria between double membranes which are infoldings of the basal cell membrane.

Coxal glands of the scorpion are embryologically homologous to the kidneys of the crayfish. As a part of a more comprehensive study of their anatomy, cytology and physiology, we investigated the ultra-structure of these organs.

The gland, which is more or less spherical, consists of two parts: (1) a medulla, which has much the same structure as the glomus of a vertebrate nephron but is, of course, devoid of any capillary endothelium, and (2) a cortex, consisting of one single convoluted tubule, arising from the central glomus, and twisted and coiled around it so as to give the whole gland a

Fig. 1. Basal β-cytomembranes in two coxal gland cells of *Euscorpius carpathicus*. *H*, Hæmolymphatic space between the cells of two adjacent tubules; *M*, mitochondria (in a fed animal)

brain-like appearance. The wall of the tubule is a one-layer epithelium of flat prismatic cells. Even at optical magnifications, these cells have much the same appearance as those of the proximal convoluted tubule of the vertebrate nephron.

On electron micrographs the similarity is striking. (1) In the basal half of the cells a crowd of mitochondria is intricately aligned in narrow compartments and separated by double membranes. (2) These membranes appear to be in every respect similar to those described by Sjöstrand and Rhodin[2] and later called 'β-cytomembranes' by Sjöstrand[3]. They are very narrow infoldings of the thin osmiophilic cell-membrane, running deep into the cell from its base. (3) At the very base of the cell, just outside this folded membrane, there is another membrane. This poorly defined, less osmiophilic layer, is probably the basement membrane of the epithelium. From optical sections, it appears to be continuous with the membrane of the glomerular wall. (4) The mitochondria are disposed in the same way as in vertebrate nephron cells. Nevertheless, their shape is quite different. Instead of being long and cylindrical, with more or less regularly spaced parallel cristæ[4], they are ovoid, with diameters of about 0·5 and 1·5μ. Their inside is a confused mass of twisted irregular cristæ, giving the whole mitochondrion a dense appearance. (5) The upper half of the cell contains a giant nucleus and a few mitochondria. They are scattered throughout the cytoplasm, particularly right under the free limit of the cell. (6) This apical limit is differentiated into a typical brush border. On electron micrographs this border clearly consists of a covering of very long microvilli, densely packed together over the whole surface. The optical microscope shows that the brush-border only extends over the proximal part of the convoluted tubule, that is, on the segment nearest the central glomus. (7) A comparison between coxal glands of starving and well-fed scorpions has shown a great difference between their respective mitochondria. In unfed animals, only a few, well-defined cristæ project into the mitochondrion, in a matrix that appears quite transparent to electrons. Rouiller and Gansler[5] showed the same kind of difference between the mitochondria of the proximal convoluted tubule in normal and starved rats.

The close similarity existing between the ultra-structure of the coxal glands and that of other organs

which are known to be excretory suggests that the coxal glands should also be regarded as excretory organs. Although this has been assumed hitherto, it was never demonstrated convincingly. In further work one of us will collect more evidence about the exact function of the gland.

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Immuno-chemical Observations on the Intimate Structure of Human Albumin

Marrack and Orlans[1], in a careful study of the behaviour of bovine albumin before and after acetylation, demonstrated that the acetylated product interacted with an antibody globulin prepared against the unmodified bovine albumin.

In a detailed study of globulins isolated from patients suffering from myelomatosis it was noted that individual globulins, homogeneous by electrophoretic and ultracentrifugal analysis, and demonstrably different from one another by these criteria, showed a common behaviour to specific antibodies to the γ_2-globulins using the technique of Ouchterlony or Oudin[2].

These observations prompted us to examine to what extent and in what way a well-characterized human albumin might be modified without materially altering its behaviour to an antibody specific to it in its natural unaltered state.

In a detailed study of the interaction of native and specifically modified albumin with metals in this laboratory, Perkins[3] had prepared a number of modifications of human albumin. Of these we examined three, choosing them because of their satisfactory analysis in the ultracentrifuge and by electrophoresis. The first modification was an acetylated albumin in which analysis indicated that about sixty amino-groups had been replaced by $-NHCOCH_3$. The second and third modifications were the products of interaction of human albumin with bromacetic acid and β-bromopropionic acid respectively. Analysis of the bromacetylated derivative indicated that thirty-six amino-groups had been substituted. The evidence from the behaviour of the protein with various metals suggested that the substitution involved the replacement of both hydrogens in the amino-groups to give $-N(CH_2COOH)_2$.

The bromopropionic derivative involved sixty-three amino-groups, the substitution most probably being that the free $-NH_2$ had been converted to $-NH(CH_2)_2COOH$.

The original batch of human albumin used in this work gave a value of eighty-seven free amino-groups in 10^5 gm. of protein.

The original albumin and the three modifications were examined by the micro-immunochemical technique of Cleve and Schwick[4] based on the method of Grabar and Williams[5].

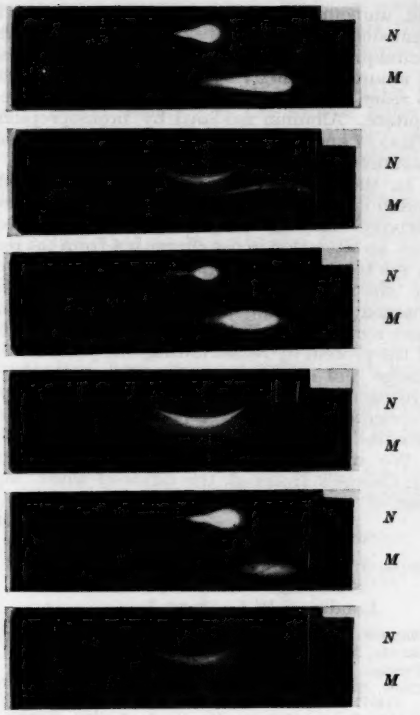

Fig. 1. Acetylated albumin. *a*, Electrophoretic analysis in agar. Analysis carried out at 20°, 2 V./cm. for 2 hr., in glycine buffer pH 8·4, ionic strength 0·05. *b*, Immuno-electrophoretic analysis in agar. Analysis carried out as above, followed by development with specific antisera for 18 hr. at 25°

Fig. 2. Albumin modified with bromacetic acid. *a*, Electrophoretic analysis in agar, as in 1*a*. *b*, Immuno-electrophoretic analysis in agar, as in 1*b*

Fig. 3. Albumin modified with bromopropionic acid. *a*, Electrophoretic analysis in agar, as in 1*a*. *b*, Immuno-electrophoretic analysis in agar, as in 1*b*

N, Native albumin; *M*, modified albumin

The replacement of 69 per cent of the free amino-groups with acetylated amino-groups in the first modification materially alters the net charge of the albumin and as a consequence its mobility. This is clearly indicated in Fig. 1*a*. The interaction with antiserum specific for unmodified human albumin is shown in Fig. 1*b*.

From these figures it is clear that proteins may differ markedly in their net surface and in their electrophoretic mobility, and yet retain their capacity to react with specific antisera.

The great proportion of the free amino-groups in albumin are the epsilon amino-groups of lysine. There is no reason to suppose that the majority of the lysine residues are concentrated in one area of the chain; therefore, to have acetylated 69 per cent of the available free amino-groups seems to imply a modification over a considerable surface area of the molecule without altering its capacity to interact with the specific antibody.

Fig. 2*a* shows the relative migration of the unmodified albumin and of the albumin after modification with bromacetic acid (lower spot). Fig. 2*b* shows the well-defined crescent of interactions between

the unmodified albumin and antisera specific for unmodified albumin using the immunochemical technique and on the same plate a parallel analysis of albumin modified by bromacetic acid, which fails to react with the specific antisera to produce a precipitate. Albumin modified by bromopropionic acid (Figs. 3*a* and *b*) behaved in the same way as albumin modified by bromacetic acid.

In the second and third modifications the free amino is replaced not by a non-polar group but by a carboxyl carrying a negative charge. There is, therefore, an alteration in net charge not from the reduction in the total of existing positively charged groups but by the replacement of certain of the positively charged with negatively charged groups. This may have a much greater effect on the secondary structure of the protein by redistributing the pattern of surface charge and may actively interfere with the normal hydrogen bonding within the chain. The resulting re-orientation would explain the failure of the modified protein to react with the antisera.

We wish to thank the Research Committee of St. George's Hospital, the funds of which supported part of this work.

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Lunar Periodicity of Aquatic Insects in Lake Victoria

Despite the constancy of their environment, certain aquatic insects in Lake Victoria exhibit periodic emergence. In the mayfly, *Povilla adusta*, emergence is closely synchronized and occurs shortly after full moon[1]. On the other hand, most swarms of 'lake-flies' (unidentified Chironomidae and *Chaoborus*) have been reported to occur shortly after new moon[2].

To investigate this matter further, a Robinson-type insect trap[3], fitted with a 125-W. mercury vapour bulb, was run near the lake-shore at Jinja (lat. 0° 25·5′ N.) for a hundred consecutive nights. The numbers caught each night of certain species of Plecoptera, Ephemeroptera, Trichoptera, Chironomidae and *Chaoborus* were counted or estimated, a procedure made feasible by modifying the trap so as to admit only about a quarter of its normal catch.

Of the thirty-seven species studied, four (apart from *P. adusta*) showed a periodic fluctuation in numbers correlated closely with the age of the moon. These species differed, however, as to the position of the peak of abundance in the lunar cycle and as to the amplitude of the fluctuation. Results for these species and for *P. adusta* are given in Table 1.

In addition, the estimated abundance of *Chaoborus edulis* Edwards (probably including a few *C. pallidipes* Theo.) also fluctuated in phase with the moon. Numbers rose abruptly to a peak five to two days before new moon (that is, at a moon age of 24–27 days), and thereafter fell gradually, so that there were several nights during the fortnight preceding a peak on which no specimens were found.

Table 1. Lunar Periodicity of Five Aquatic Insects in Lake Victoria

Group	Species	Age of moon to nearest day	
		Abundance peak	Range of captures
Ephemeroptera: Polymitarcidae	*Povilla adusta* Navas	17–18	15–4
Trichoptera: Leptoceridae	*Athripsodes stigma* Kimmins	23–29	Every day
	Athripsodes ugandanus Kimmins	8–9	Every day
Diptera: Chironomidae	*Clinotanypus claripennis* Kieffer	7–8	28–11
	Tanytarsus balteatus Freeman	2–5	Every day

That catches in a light-trap may reflect activity as well as emergence or abundance of insects has frequently been emphasized, and it is important where possible to assess the relative effects of these factors. The asymmetrical pattern of abundance of *C. edulis* gives a firm indication that here it is caused primarily by a corresponding rhythm of emergence rather than activity. Observations of five day-time swarms of *Chaoborus* at Jinja, all of which have been 4–2 days before new moon, support this.

The more symmetrical pattern of abundance of *Tanytarsus balteatus* (Fig. 1) might appear at first to support the idea, recently discussed[4], that catches in a light-trap are greatest near new moon and least near full moon owing to an artefact effect resulting from changes in the relative brightness of the trap at different phases of the moon. However, positions of the peaks and troughs relative to new and full moon do not confirm this interpretation, and it appears more likely that the pattern is caused by a lunar rhythm of emergence in which the population is poorly synchronized. The same is possibly true of *Athripsodes stigma* and *A. ugandanus*.

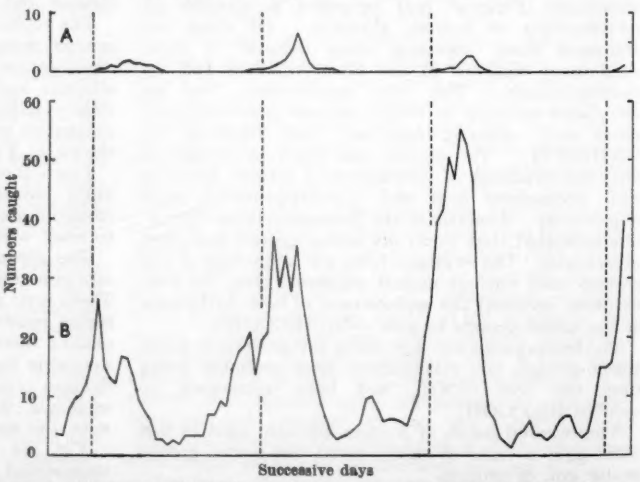

Fig. 1. Numbers caught nightly of (*A*) *Clinotanypus claripennis* and (*B*) *Tanytarsus balteatus* in relation to new moon (shown by vertical dotted lines). Results smoothed by a sliding geometric mean of 3

In the remaining species studied, no cyclical fluctuation in numbers could be discerned. This has two implications of interest: first, it demonstrates that emergence and reproduction of many aquatic insects in equatorial lakes need not be cyclical; and second, it shows that, in the groups studied, the hypothetical artefact effect mentioned above does not influence catches in a light-trap to a significant extent.

It is intended to publish a full account of this work elsewhere.

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Preservation of Grass for Winter-feeding by Radiation Sterilization

IN the course of investigations on microbial decomposition of grass carried out at Hurley by one of us (E. G.), a method of sterilization was sought which would not alter appreciably the chemical and physical structure of grass. Ionizing radiation gave the most promising results. It was then decided to explore the possibilities of preserving grass for winter-feeding on a purely experimental basis by this method. A preliminary account by Grossbard *et al.*[1] was published in 1957. Radiation sterilization of meat, dairy products, grain and other materials has been studied extensively. The results have been reviewed by Hannan[2], Comar[3] and others.

Irradiation of small experimental samples (50–100 gm.) of ryegrass (*Lolium perenne*) tightly packed in cylindrical containers of polystyrene were carried out at the Wantage Radiation Laboratory. A cobalt-60 source was used and dosages of 1×10^6 to 4×10^6 rads were applied. Extensive sterility tests showed that a dose of 2×10^6 rads $\pm$ 10 per cent was adequate for complete sterilization. This agrees with the findings of other workers using different biological materials.

The samples were stored for periods of 6–18 months. Irradiation in itself did not cause any conspicuous changes in the physical appearance of the grass. However, a characteristic though not unpleasant odour developed immediately after irradiation. Samples kept in the dark at 4° C. retained their green colour up to six months, while those stored in the light at laboratory temperatures turned a straw colour after two to three months. Possibly factors other than temperature and light will affect persistence of chlorophyll.

Recently, exploratory experiments were carried out on larger samples ranging from 500 to 2,000 gm. tightly packed in polyethylene bags or tinned cans. A total of 30–40 kgm. was irradiated at any one time either from a cobalt-60 source or a 4-MeV. linear accelerator. The results obtained using the accelerator were inconsistent in themselves owing to the difficulty of measuring the dose delivered to the grass.

Batches of this irradiated grass were then fed to experimental sheep. A total of six animals was used for this test. Whether this grass was fed immediately following irradiation or after a month of storage the sheep soon became accustomed to it. While our results are of necessity on a small scale, it appears that irradiation in itself does not interfere appreciably with the palatability of the grass.

It is intended to irradiate larger bales of grass in the spent fuel-rod assembly at the Atomic Energy Research Establishment, Harwell, and to carry out more extensive trials on palatability, digestibility and the nutritional value of irradiated grass.

Another problem which is under investigation is a suitable container in which to pack and store the grass. We find that in polyethylene bags recontamination readily occurs, possibly owing to changes which have taken place in the plastic as a result of irradiation. Small sample bags of 'Metathene' (a polyethylene-'Cellophane' laminated film produced by the Metal Box Co.) filled with grass and placed inside the polyethylene bags also containing grass were more resistant, and while recontamination occurred on storage the percentage was lower than in polyethylene bags. So far the tin cans proved to be the most suitable containers.

We wish to thank Mr. W. F. Raymond for his interest in this work and Mr. G. E. Outen for valuable technical assistance.

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Polarization of Light of the Comets [Arend-Roland (1956*h*) and Mrkos (1957*d*)

POLARIZATION of the total light of the Comets 1956*h* and 1957*d* was studied photographically by simultaneous exposures with three objectives and three 'Polaroids'. The planes of polarization of the three 'Polaroids' were at 120°. 2-in. objectives were used at *f*/9 with Agfa 'Astro' panchromatic plates. The characteristic curve was determined by comparison with an exposed photometric wedge. Errors due to the instrument were measured by means of light from an artificial source, polarized to a known degree by reflexion from a glass surface. The error of the polarization determined is $\pm$ 2·5 per cent.

Altogether we obtained seven plates of the Comet 1956*h*, during April 27–May 29, 1957. Only five of them, however, were suitable for detailed measurement. The Comet 1957*d* was photographed three times, but only two of these plates, during August 20–23, 1957, were measured. This was done with a self-recording microphotometer, using a square slit with an area of 0·005 mm.^{2}. In the case of the Comet 1957*h*, where the phase-angle θ was 58° or 69°, respectively, the values found were reduced for $\theta = 90°$. The results of our measurements are shown in Tables 1 and 2.

Table 1. Degree of Polarization (per cent) of the Light from Comet Arend-Roland 1956*h*

Date (1957)	Phase angle, θ	Distance from the head (min. of arc)								
		3	4	5	6	8	10	12	14	16
April 27	98	18·9	22·4	23·5	23·2					
,, 27	98	21·7	21·9	23·4	23·8	26·6	27·1			
,, 29	92	11·2	14·9	15·2	17·4	18·5				
May 1	85	11·9	15·1	17·2	15·2	20·7				
,, 2	81		12·8		15·7	18·2	17·5	19·1	18·9	19·2

Table 2. Degree of Polarization (per cent) of the Light from Comet Mrkos 1957*d*

Date (1957)	Phase angle (θ)	Distance from the head (min. of arc)				
		3	4	5	6	8
August 20	63	10·8	10·5	10·5	10·8	
,, 23	59·5	10·8	8·2	8·4	7·7	10·9
		For phase angle θ = 90°				
,, 20		14·1	13·7	13·7	14·1	
,, 23		15·1	11·3	11·6	10·7	15·3

Using these results, we came to the following conclusions: (1) The degree of polarization in the tail of the Comet 1956*h* decreases towards the head, but is fairly constant at large distances from the coma. (2) There was a sudden decrease of the degree of polarization in the whole tail of the Comet 1956*h* between April 27 and 29. (3) The degree of polarization in the tail of the Comet 1956*h* agrees with values found by other observers[1–3], though that of Barber[4] is extremely high compared to ours. (4) The degree of polarization in the tail of the Comet 1957*d* is distinctly lower. In contradiction to the results of Barber[4], the polarization of light from this comet may be explained as predominantly due to pure molecular emission. On the other hand, the higher values found for Comet 1956*h* may be explained by an increased proportion of light scattered by dust particles. This also agrees with the published spectrographic results, which indicate that the continuous spectrum was also extraordinarily prominent in Comet 1956*h*. The colour index, measured by Tremko and Vanýsek[5], was found to be + 0·59 in the *BV* system for the Comet 1956*h*, very close to the colour index of the Sun, but it was as low as + 0·19 in the light of Comet 1957*d*.

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Correlation of Whistlers and Lightning Flashes by Direct Aural and Visual Observation

Extending the theoretical work of Eckersley[1], and combining it with extensive experimental observations, Storey deduced that whistlers result from the energy of very low frequency radiated by lightning flashes, propagated up to great heights along the flux of the Earth's magnetic field and down again to the ground at the geomagnetically symmetrical place in the opposite hemisphere, taking a second or two to make this very long trip. The lower frequencies travel more slowly than the high, so that the original impulse is spread out into a swish or whistler of descending pitch when it is received[2].

Allcock and I have reported that the simultaneous observation of whistlers at conjugate points in the northern and southern hemispheres bears out the essential details of Storey's hypothesis, and Helliwell and Gehrels have found that very low-frequency broadcast signals can be received in the opposite hemisphere after propagation in the whistler mode[3].

Helliwell, Gallet and Ellis have each noted independently that, above a certain frequency, the dispersion must reverse. This was first verified by Helliwell[4,5].

Throughout this development, there has remained the disquieting fact that nearly all known attempts to observe lightning by visual perception and to hear a resulting whistler have been unsuccessful. Eckersley reported that "K. Tremellen has found that Isolated Whistlers are definitely caused at certain times by local lightning flashes"; and Dinger and I have communicated an observation by A. G. Jean[1,6]. Because these reports have not been sufficiently elucidated, or readily duplicated, there have been persistent suggestions that whistlers may not be generated by lightning.

In 1957, on May 27 at about 0215 *Z* at Hanover, N.H., I noted a distant lightning flash in the night sky. Turning to a whistler receiver I heard almost continuous whistler activity. The whistlers were the long or round-trip type, followed by echo trains. Their intensity was not great, and it was not possible at that time to detect any correspondence with the visible lightning flashes which were continuing. In time, the storm producing the flashes came closer until thunder could be heard. By then, I observed that some flashes were producing weak whistlers, but the majority still were not. As the storm continued its advance, the flashes became less frequent and the resulting 'sferics' became noticeably shorter in duration and greater in intensity (by aural perception). By about 0500 *Z*, every visible flash was producing a strong whistler with several echoes and there were no other whistlers present. Flashes were occurring about three minutes apart and there were no other 'sferics' present except a steady barrage of very weak tweeks.

This situation persisted for about an hour, after which the flashes became still less frequent and I finally saw no more. Coincidentally I heard no more whistlers. Throughout, the clouds hung low and there was much mist near the ground. Heavy rain fell at times. Although the flashes lit up the countryside, I could not see the discharge paths from my position.

From this successful observation, and many unsuccessful ones of the past, it is concluded:

(1) that lightning flashes can generate whistlers, (2) that most lightning flashes do not generate whistlers.

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A Simple Device for observing the Polarization of Light from the Sky

CHAPMAN[1] has recently described a device for visualizing the pattern of plane-polarized light from blue sky, which seems to be unnecessarily complicated and expensive.

The ability of certain animals to perceive the polarization of light is not entirely absent in man. In the human eye polarized light causes an 'entoptic' phenomenon called Haidinger's brushes. This consists of two yellow sheaves radiating in opposite directions from the point of fixation. The sheaves are flanked by blue hyperbolic regions. The axis of the blue hyperbola corresponds to the plane of vibration of the electric vector of linearly polarized light, which is at right angles to the 'plane of polarization'. It is quite easy to see Haidinger's brushes by rotating a polarizer slowly before the eye, but to use the phenomenon to study the polarization of the light from the sky is difficult as the percentage of polarized light is never very large. After some training it is, however, often possible.

A simple sky-compass was constructed by Tschermak-Seysenegg[2] from a rectangular piece of 'Polaroid' with the optical axis parallel to one of the sides of the rectangle. From this are cut out (as shown in Fig. 1) 12 isosceles triangles with their bases parallel to the long side of the rectangle and with their top angles 30°. These triangles are then arranged to a regular dodecagon. If one looks at the sky through this 'radial analyser' light and dark sectors are seen, as with Chapman's device.

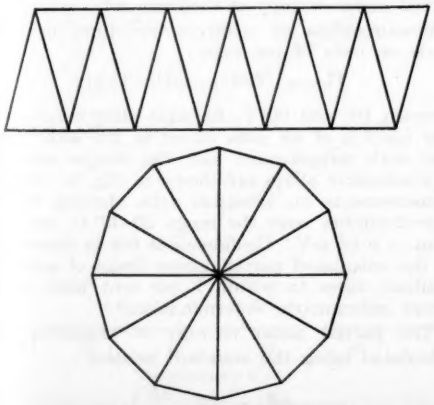

Fig. 1

The sensitivity of this simple apparatus is increased by combining the 'radial analyser' with a 'radial retarding plate'. I have used 'Cellophane'[3] as the birefringent material. Double layers of 'Cellophane' are pasted on a piece of 'Polaroid'. The optical axis of the tape (which is parallel to the fine striation of the material) is kept at 45° to that of the 'Polaroid'. The whole is then cut into triangles and arranged to form a dodecagon as above. In this way the sectors appear yellowish-green and purple and are easy to observe even if the percentage of polarized light is small.

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Verdet Constants of Rare-Earth Glasses measured with a New Polarimeter

IN some optical devices the Faraday effect is used with advantage as a shutter, and, as a modulator of a light beam, it is especially useful in polarimetry[1–3]. In such applications a material having a large value of the Verdet constant is usually sought, consistent with adequate transmission at the desired wavelengths. While numerous materials, especially thin metal films and ferrites, are known which have large absolute values of the Verdet constant[4], measurements reported here are limited to glasses.

From the data published by Cole[5] the Verdet constants of silicate glasses not containing rare-earths are seen to be approximately proportional to the reciprocal of their constringence, and positive. Therefore, a low-power magneto-optic modulator using the Faraday effect has often depended upon the use of a dense flint glass of low constringence.

It was discovered here that there is at least one readily available glass the Verdet constant of which is negative : didymium filter glass, type *ON*16 (Chance-Pilkington Optical Works, Ltd.). The negative Verdet constant of this glass raised the question of how the Verdet constant would depend upon the presence of a paramagnetic rare-earth in a glass.

A preliminary examination with a visual polarimeter of some experimental glasses, obtained from the research laboratories of Messrs. Pilkington Brothers, Ltd., was then made. These glasses contained a constant proportion of boric oxide, and samarium oxide replacing lanthanum oxide from 0 to 65 per cent by weight. It was found that their Verdet constants, while positive in sign, decreased with increasing samarium content.

Finally, the Verdet constants of a number of borate glasses specially made by the above Research Laboratories and containing graded proporti ons of the paramagnetic rare-earths gadolinium and dysprosium were measured using the recently available *ETL-NPL* automatic polarimeter.

The operation of this polarimeter has been described elsewhere[6], but it should be noted that the activity of a sample in this polarimeter appears as an analogue electric current. In these experiments this current was measured using an adjustable shunt and a potentiometric chart recorder.

The optical activity was measured using an incandescent source filtered in the neighbourhood of mercury green with a half-intensity width of 200 A. A reduced aperture was used so that the beam crossing the sample had a diameter of 2 mm.

The various samples were polished plane-parallel to thicknesses between 2 and 3 mm., and were left as fragments of less than $\frac{1}{8}$ in. in any other dimension.

An axial magnetic field of about 1,120 gauss was provided in a sample holder which used two axially polarized permanent magnets of an annular shape. The flux path of each magnet was nearly completed with turned soft-iron washers having a conical inside surface perforated with a central $\frac{1}{8}$-in. hole, and leaving an axial gap of $\frac{1}{8}$ in. to contain the sample. Two such assemblies with their magnetic fields in opposition were mounted within a plastic holder having an outside diameter of 30 mm. Only one magnet assembly was used to contain the sample, and the magnetic fields of the two tended to cancel, so that the effect of stray magnetic fields upon the polarimeter was reduced to less than 0·008° arc and could be corrected for. During the course of some fifty measurements where the sample holder was dismantled and re-assembled each time, the effective field-strength H was found to have decayed by less than 1 per cent.

The effective field-strength H in the perforated gap of the sample holder can be found by referring the observed magneto-optic rotation of fused quartz α_q to the known Verdet constant V_q of fused quartz[7] (16·64 min./kilogilbert):

$$H = \alpha_q / V_q p_q \qquad (1)$$

where p_q is the path-length. Measurements of the Verdet constants of the rare-earth glasses were then made referring to the Verdet constant of fused quartz. Thus, if the observed sample rotation α_s in a path-length p_s corresponds to a sample Verdet constant V_s:

$$V_s = \alpha_s / H_s p_s \qquad (2)$$

Upon substituting the value of H from (1) then,

$$V_s = V_q(\alpha_s/\alpha_q)\ (p_q/p_s) \qquad (3)$$

Chart records of the optical activity of the fused quartz reference and of the sample glasses were usually made alternately, and the ratios of optical activity taken from adjacent traces. The chart record was also convenient in observing the birefringence of the samples, as an oscillatory trace was obtained when the sample holder, together with the sample in it, was slowly turned about the optical axis. The activity of the sample was then taken as the average value of the trace over at least four cycles.

In all cases the birefringence greatly exceeded the inherent noise-level of the instrument, which was 0·001° arc in a 1 c./s. bandpass. The total excursion of the recorder trace due to residual birefringence is recorded in Table 1 as per cent of the mean optical activity.

The Verdet constants of the six new rare-earth glasses are listed in Table 1. The six samples all contained 37·5 per cent by weight boric oxide, and the balance both lanthanum and the paramagnetic rare-earth oxide.

For the comparison, the Verdet constant of a didymium filter glass, and the most dense flint glass available for construction of a Faraday cell, are included in Table 1.

Table 1

Glass	V_s (min./kilogilbert) λ = 546 nm.	Mean deviation (per cent)	Amplitude of birefringence (per cent)
Didymium *ON* 16	−25·3	1·2	18·0
10 wt. per cent Gd_2O_3	21·2	5·6	43·0
20 ,, ,, ,,	20·5	4·6	64·0
30 ,, ,, ,,	19·8	2·2	25·2
10 ,, ,, Dy_2O_3	−35·2	3·7	22·0
20 ,, ,, ,,	−93·8	3·0	12·8
30 ,, ,, ,,	−150·0	2·7	6·7
030181	151·0	—	—

These results show that certain glasses can have negative Verdet constants comparable in magnitude with that of the densest flint glasses.

It would be interesting to find out in more detail just how the presence of the paramagnetic rare-earth ion is related to the Verdet constant, and whether much greater Verdet constants could be obtained.

I am indebted to Mr. J. Kowal for making many of the measurements reported here, and to the Controller of Research, Dr. J. H. Mitchell, for permission to publish this paper.

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Ordering in Liquid Mercury–Thallium Alloys containing 25–35 Atomic per cent Thallium

Recent X-ray measurements on liquid mercury–thallium alloys have given some evidence for ordering at compositions corresponding approximately to the solid-state compound Hg_5Tl_2 [1]. These results, obtained at 17° C., some 3° C. above the melting point of Hg_5Tl_2, are unfortunately inconclusive due to the uncertainty introduced by the extensive corrections necessary in the analysis of diffraction data. In the present work, evidence for the existence of ordering has been obtained by accurate determinations of the partial molar entropy of thallium, S^M_{Tl}.

Measurements of electromotive force have been made on cells of the type:

$$Tl_{(cry\ t.)}/TlSO_{4(aq.)}/Hg–Tl_{(liq.)}$$

between 10° and 90° C. for nine alloy compositions. The e.m.f.'s of all cells varied in the same general way with temperature, and the results with three representative alloys are shown in Fig. 1. Duplicate measurements on identical cells showed that the reproducibility over the range 20–35° C. was better than ± 0·02 mV. Confidence is felt in these results, as the calculated partial molar heats of solution of thallium agree to within 7 per cent with accepted direct calorimetric determinations[2,5].

The partial molar entropy of thallium, S^M_{Tl}, is calculated using the standard relation:

$$S^M_{Tl} = nF\left(\frac{\partial E}{\partial T}\right)_{N,P}$$

and $S^M_{\Delta 1}$ for the range 20–35° C. is given in Fig. 2. The e.m.f. values above 50° C. were much less reproducible, and the error introduced into the $S^M_{\Delta 1}$ values in this range renders them valueless for the present purpose.

The variation of S^M_{11} with composition in the range 20–35° C., Fig. 2, is characteristic of solutions showing short-range order[3,4], and confirms the earlier inconclusive evidence for ordering from X-ray measurements[1]. This effect was not noticed by previous workers[5], who used more widely spaced compositions. For an ideal random solution this plot would be linear with gradient $-R$, but short-range ordering introduces a deviation to lower entropies at concentrations below the ordering composition, and a symmetrical swing to higher entropies at higher concentrations[3,4]. The 'cross-over' composition at 29·4 atomic per cent thallium indicates that ordering occurs at the composition $Hg_{12}Tl_5$; this formula could equally well be assigned to the solid-state compound for which Hg_5Tl_2 (28·6 atomic per cent thallium) was originally proposed, as both compositions fall within the limits of accuracy of the equilibrium phase determinations[6].

The change in entropy in the ordering region (27–32 atomic per cent thallium) is quite small (± 0·3 J.E.U.), indicating rather feeble ordering, which would account for the difficulty in detecting ordering in the diffraction studies[1]. The low heat of formation of the solid alloy[7] of −0·35 kcal./gm.-atom also suggests a feeble tendency to compound formation.

The increasing gradient of the e.m.f. vs. temperature plots (Fig. 1) between 35° and 50° C. indicates an increase in the entropy of thallium which may reasonably be interpreted as an increase in atomic randomness over this temperature-range. This occurs at all alloy compositions, and approximate

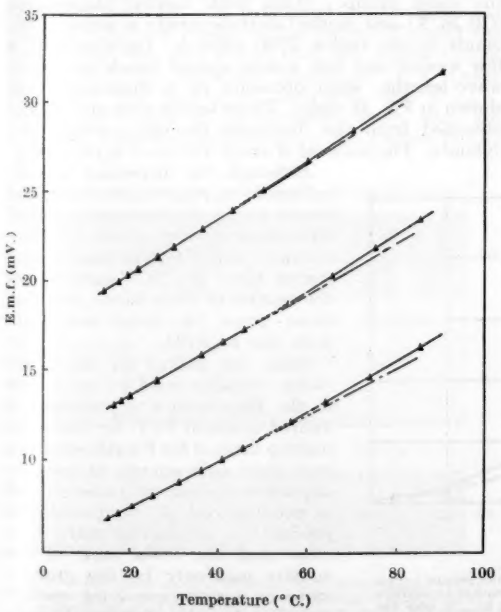

Fig. 1. Typical plots of e.m.f. (mV.) vs. temperature (° C.). Top, $N_{Tl} = 0·2480$; centre, $N_{Tl} = 0·2917$; bottom, $N_{Tl} = 0·3437$

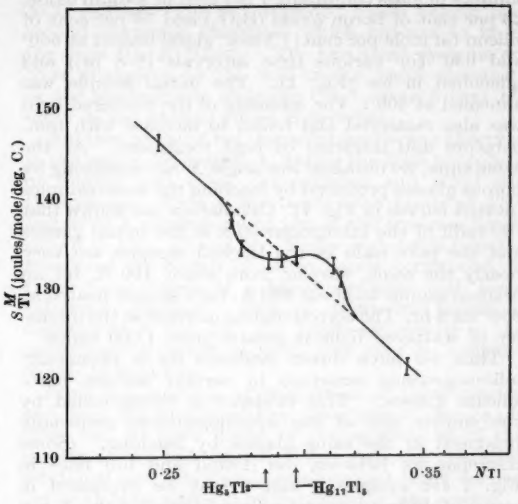

Fig. 2. Partial molar entropy of solution of thallium (S^M_{Tl}) vs. log composition (mole fraction thallium) at 20° C. The estimated errors in the experimental points are indicated

entropy values from the upper slopes of the curves indicate that complete randomness is not attained; it seems likely that the change is one of co-ordination. Accurate entropy values above 50° C. are necessary to clarify this position, and attempts are now being made to obtain stable reproducible e.m.f.'s between 50° and 90° C.

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Low-Angle X-Ray Scattering by Glasses

There have been reports on the discovery of low-angle X-ray scattering by glasses, and evidence has also been presented to the contrary[1–4]. In trying to produce low-angle X-ray scattering by various types of glasses it became apparent to us that spurious effects might arise when using powder samples, owing to the surface scattering by the grains of the ground glass. This consideration also made us doubt the results of Hoffman and Statton[3].

In our further attempts to obtain low-angle X-ray scattering we used polished glass plates, about 0·2 mm. in thickness. Complete absence of any surface effects was ensured by varying the thickness of the samples. The X-ray exposure was carried out in an evacuated chamber with Kratky collimation[5]. Filtered copper K_α-radiation was used with a sample-to-film distance of 350 mm.

We succeeded in producing a clear and reproducible low-angle X-ray scattering pattern for a series of

samples of glass containing 7 per cent of sodium oxide, 23 per cent of boron oxide (B_2O_3) and 70 per cent of silicon (in mole per cent) ('Vicor' glass) heated at 600° and 650° for various time intervals (1–8 hr.) and quenched in air (Fig. 1). The initial sample was annealed at 500°. The intensity of the scattered light was also measured and found to increase with temperature and duration of heat treatment. At the same time, we obtained low-angle X-ray scattering by porous glasses produced by leaching the same samples (dotted curves in Fig. 1). Calculation has shown that the radii of the inhomogeneities in the initial glasses and the pore radii in the leached samples are very nearly the same, varying from about 100 A. for an original sample to about 900 A. for a sample heated at 650° for 6 hr. The corresponding increase in the intensity of scattered light is greater than 1,000 times.

Thus we have direct evidence for a chemically inhomogeneous structure in certain sodium borosilicate glasses. This evidence is strengthened by the similar size of the inhomogeneities artificially produced in the same glasses by leaching. (Some discrepancies between the dotted and full lines in Fig. 1 for samples 5 and 6 may be explained in terms of different operating conditions for the X-ray tube during the exposure of the glasses mentioned, namely, 30 kV. for the original and 15 kV. for the porous glasses.)

The observed intensity of the low-angle X-ray scattering is very low. Indeed, whereas porous glasses require exposure times of the order of several minutes, many scores of hours are needed when examining the original glasses. The reason lies in a very small difference between the electron densities in the chemically inhomogeneous regions. For the glasses investigated, this difference, calculated from the electron density of vitreous silica and the ratio of X-ray intensities scattered by the original and the porous glasses, is only about 0·04 electron/A. This explains why the attempts at producing low-angle X-ray scattering by other types of glasses have failed. These would also have considerably smaller inhomogeneities (if there were any at all), which would greatly increase the exposure time required. For example, an exposure of more than 2,000 hr. would be required with our apparatus to produce scattering by the same 'Vicor' glass with an inhomogeneity size of 50 A. To reveal such small chemical inhomogeneities considerably more sensitive apparatus should be used.

A complete report of this work will be published in the Chemistry Section of *Transactions of the Academy of Sciences of the U.S.S.R.*

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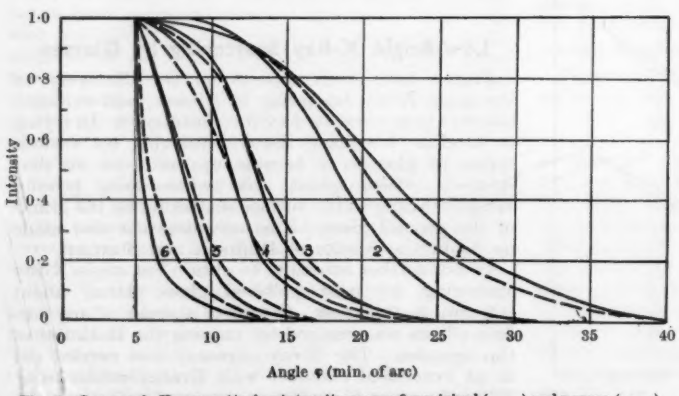

Fig. 1. Low-angle X-ray scattering intensity curves for original (——) and porous (– – –) glasses obtained by heat treatment of the original glasses as follows (relative intensities of light scattering are shown in brackets): 1, 500° (1); 2, 600° for 2 hr.; 3, 600° for 4 hr.; 4, 600° for 8 hr. (3·4); 5, 650° for 1 hr. (30); 6, 650° for 6 hr. (> 1,000)

Emission and Absorption Spectra of NCO and NCS

Several polyatomic free radical spectra have been observed in fluorescence when various compounds are irradiated with Schumann ultra-violet radiation. Neuimin and Terenin[1] observed the spectrum of NH_2 in emission with this technique, and Style and co-workers have reported several fluorescence spectra which they have assigned to HCO (ref. 2), HCOO (ref. 3), CH_3O (ref. 4) and C_2H_5O (ref. 4).

A few years ago, two of us (R. H. and D. W. G. S.) observed a series of bands in the region 4250–4650 A. in the fluorescence from ethyl *iso*cyanate (C_2H_5NCO). The bands were also observed in emission from a high-frequency discharge through this compound at a pressure of about 1 mm. mercury. A reproduction of the bands excited by this latter technique is given in Fig. 1*a*. The principal feature is a group of strong bands in the region of 4400 A. A similar, but much weaker, group lies 1,275 cm.$^{-1}$ to lower frequencies of the main group. With both methyl thiocyanate (CH_3SCN) and methyl *iso*thiocyanate a series of ten bands in the region 3750–4850 A., together with a few weaker and less widely spaced bands at shorter wave-lengths, were obtained as a fluorescence, as shown in Fig. 1*b* and *c*. These bands were also readily obtained from the discharge through methyl thiocyanate. The interval of about 700 cm.$^{-1}$ is prominent.

Although the dispersion was insufficient to resolve the rotational fine structure, the fact that identical fluorescences were given by thiocyanate and *iso*thiocyanate suggested that the NCS radical was the emitter of these bands, and that those given by ethyl *iso*cyanate were due to NCO.

Since the energy of the ultra-violet radiation used for excitation in the fluorescence experiments is limited to about 9 eV. by the transmission limit of the fluorite windows, and since this energy is used to dissociate the parent molecule and to produce one of the dissociation products in an excited state, it is clear that the lower state of the emitter can only be the ground-state or a very low lying excited state. In the former case it

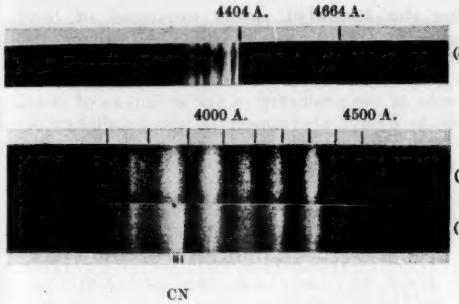

Fig. 1. Emission spectra of NCO and NCS. *a*, High-frequency discharge through C_2H_5NCO, glass spectrograph; *b*, *c*, fluorescence from CH_3NCS and CH_3SCN, respectively, quartz spectrograph

should be possible to observe the spectrum in absorption.

Experiments were therefore carried out at Ottawa on the flash photolysis of the above compounds in an attempt to obtain these new spectra in absorption. The apparatus was similar to the one described earlier[5]. Four photolysis lamps were used, each being fired by a 33-μF. condenser charged to 7 kV. The reaction cell was 50 cm. long and multiple reflexion mirrors were used to increase the optical path-length to 10 m. The spectra were photographed using a 21-ft. concave grating spectrograph.

During the flash photolysis of ethyl *iso*cyanate at 5 mm. pressure several violet degraded bands were observed in absorption in the region 3600–4500 A.; in addition, seven red degraded bands were observed between 2620 and 3160 A. The bands were observed with increased intensity during the flash photolysis of *iso*cyanic acid, HNCO. The strongest violet degraded absorption band is reproduced in Fig. 2*a* and corresponds to the strongest band observed in emission (Fig. 1*a*). A typical red degraded band is shown in Fig. 2*b*. A rotational and vibrational analysis of several of the violet degraded bands has been carried out and shows that the bands belong to a $^2\Sigma$—$^2\Pi_i(a)$ electronic transition of a linear molecule. The rotational constants are $B'_{000} = 0{\cdot}402_1$ cm.$^{-1}$ and $B''_{000} = 0{\cdot}389_4$ cm.$^{-1}$ and are consistent with the assignment of the carrier to the NCO radical. The red degraded bands belong to a second electronic transition which appears to be of the type $^2\Pi_i(a)$–$^2\Pi_i(a)$. The two band systems are thus analogous to the well-known band systems[6,7] of the isoelectronic molecule CO_2^+, except that the order of the excited states is reversed.

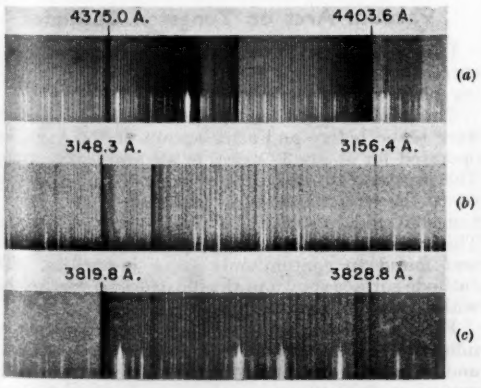

Fig. 2. Absorption bands of NCO and NCS photographed with a 21-ft. grating spectrograph during flash photolysis experiments: *a*, strongest band of the violet degraded system of NCO from HNCO; *b*, a typical band of the red degraded system of NCO from HNCO; *c*, a typical sub-band of NCS from CH_3SCN (diluted with argon)

Another series of red degraded bands was observed in the region 3350–4000 A. during the flash photolysis of methyl and ethyl thiocyanates and ethyl *iso*-thiocyanate. Two of the bands with heads at 3712 and 3820 A. correspond to two of the emission bands shown in Figs. 1*b* and 1*c*. Under high resolution the rotational structures of these bands correspond to $^2\Pi_{\frac{1}{2}}(a)$–$^2\Pi_{\frac{1}{2}}(a)$ bands of a linear molecule with large sub-band spacings. One of these sub-bands is reproduced in Fig. 2*c*. The bands are similar to the corresponding bands of NCO and may be assigned to the NCS radical.

From the methods of production of these spectra and from the rotational fine structures of the bands there can be little doubt of the assignment of the spectra to the NCO and NCS free radicals. Detailed rotational and vibrational analyses are being carried out at Ottawa and will be published in due course.

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Cadmium Bromide: Growth Spirals and Possible Polytypism

In recent years growth spirals have been observed on crystals of nearly thirty[1] substances. Detailed descriptions of these markings, as well as their relationship to screw dislocations, have been given especially of crystals of silicon carbide[1,2] and cadmium iodide[3]. I wish to report the occurrence of growth spirals on crystals of cadmium bromide ($CdBr_2$), and to comment on their implications regarding possible structural polytypism in this compound.

Numerous spiral markings have been observed on the (0001) faces of cadmium bromide crystals. These crystals, which measure approximately 0·2 mm. across, were grown from an aqueous solution of cadmium bromide, reagent grade ($CdBr_2.4H_2O$), to which a liberal amount of hydrobromic acid had been added. For the most part the markings are circular with a slight suggestion of hexagonal or triagonal shape. Both left- and right-handed spirals occur. Single spirals are present, but combinations and intergrowths of spirals are more common. Fig. 1*A* shows a marking produced by three screw dislocations of the same sign, sufficiently close together

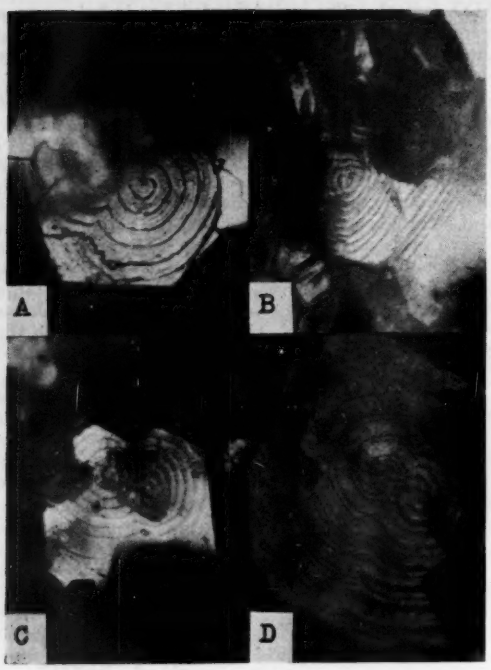

Fig. 1. Photomicrographs of growth spirals on crystals of cadmium bromide ($CdBr_2$). Vertically reflected light. (× 216)

for co-operation with one another. The Burgers vector of one of the dislocations is greater than the other two, thus producing the more prominent spiral step. More complicated patterns were seen in which the distance of separation of the dislocations was greater. Frequently one observes spirals formed from two or more dislocations of opposite sign. Fig. 1*B* shows a case where two dislocations of opposite sign, and of the same Burgers vector, have interacted to form closed triangular loops. Fig. 1*C* illustrates a case where two spirals of opposite sign and some distance apart interacted with each other. This looks like a case in which two crystals have joined and then grown. Many other more complicated cases were observed in which dislocations of the same and opposite signs and different Burgers vectors result in interacting spiral markings (Fig. 1*D*).

Recent studies have shown a relationship between structural polytypism and the spiral growth of crystals resulting from screw dislocations in silicon carbide[4] and cadmium iodide[5] structures. From a knowledge of these studies, I propose that a series of polytypic structures may also exist for cadmium bromide. Normal cadmium bromide, designated as 6*R* by Ramsdell's[6] notation, has an ideal structure represented by $[(A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$, in which bromine ions are represented by Roman letters and cadmium ions by Greek letters in the common notation for the closest packing of spheres. The following structural series might be formed by various single dislocations in this ideal structure :

2*H*, $[(A\gamma B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
8*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
14*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
20*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\alpha B)]_n$, etc.

Using the Ramsdell zigzag sequence[6] of bromine ions in the $(11\bar{2}0)$ cross-section, the hexagonal series could be represented by (1,1), (7,1), (13,1), (19,1) . . . $(n6 + 1,1)$, where n is either zero or an integer. From a study of the geometry of the structure of cadmium bromide I have also conceived the possibility of less common dislocations producing a second series of polytypes :

4*H*, $[(A\gamma B)\ (C\alpha B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
10*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\alpha B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
16*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\alpha B)]_n$
6*R*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$
22*H*, $[(A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\beta A)\ (B\alpha C)\ (A\gamma B)\ (C\alpha B)]_n$, etc.

The zigzag sequence symbols for the hexagonal forms are : (2,2), (8,2), (14,2), (20,2) . . . $(n6 + 2,2)$. In both these series the ideal structure 6*R* always results when the Burgers vector strength is a multiple of 6. Co-operating dislocations of mixed signs and Burgers vector strengths would, of course, generate other more complicated polytypic structures.

I am currently engaged in an X-ray study of this compound to ascertain if some of the predicted structures exist. I have verified the ideal structure and found the 4*H* form as well as strong evidence for other polytypes. In an earlier study, Pinsker[7] reported the existence of 2*H* and 4*H* forms. The results of the present X-ray study will be published in due course.

This work is being financed by a Research Corporation Frederick Gardner Cottrell grant.

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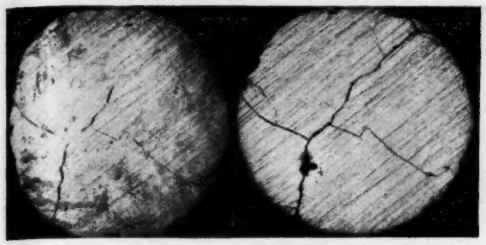
Vacuum Arcs on Tungsten Cathodes

In the course of a programme of work on direct-current arc discharges at low gas pressure an interesting phenomenon was encountered.

Photomicrographs of tungsten cathode surfaces were taken before and after an arc of 150 amp. had operated for about 30 msec. in air at 1μ of mercury. The arc was initiated by touching a pointed anode on to the cathode surface. Both electrodes were of tungsten rod, as used for inert electrode welding. This material was later analysed spectroscopically and found to contain only trace impurities. The cathode surface shown in the illustrations was finished with grade 3–0 polishing paper.

Fig. 1*a* shows a ¼-in. diameter cathode, at a magnification of six times, before the arc occurred, and Figs. 1*b* and 2 show the same surface after arcing at magnifications of six and seven hundred respectively.

It can be seen that small areas of tungsten have been melted and the craters are distributed along fine cracks which were present before arcing.



a *b*

Fig. 1. Photomicrographs of a tungsten cathode surface. Arc current 150 amp., residual gas, air at 1μ mercury pressure, arc duration about 30 msec. *a*, Before arcing; *b*, after. (× 6.) The dark marking in the bottom left quadrant of *b* is the point of contact of the electrodes

Photomicrographs at high power (× 1,000) of the same section of the cathode surface, before and after arcing, show conclusively that melting occurs only on the cracks, when these exist. Results on specimens without cracks show isolated patches of overlapping craters, the surface in between appearing quite undisturbed—at least under visual observation at magnifications up to a thousand.

Other experiments, which will be reported in full elsewhere, indicate that vacuum arcs on both refractory and non-refractory cathodes behave like cold cathode arcs and have a small, mobile cathode spot region. Using a fine crack on a tungsten cathode to 'guide' the cathode spot, attempts were made to photograph this region using high-speed ciné photographic techniques. The experiments were unsuccessful. It is considered quite possible that the cathode spot does not move along the track at all, but has a random motion and only melts the tungsten when it crosses the sharp edge of a crack.

The melting is never continuous, although simultaneous oscillograms show the arc voltage to be continuous, though fluctuating.

The craters are very small in area, for example, some of those shown in Fig. 2 are about a micron in radius, giving an area of only about 3×10^{-8} cm.^{2}, Now, although the total arc current is 150 amp.. 'spot splitting' occurs, that is, there are many small cathode spots active, 'in parallel'. Thus the current associated with each crater is not known, but it is considered that it is at least 1 amp. and very probably more. Also, the actual area over which electron emission occurs may be greater than the melted area, but even when this is borne in mind, these results indicate an extremely high current density at the cathode. Values between 10^7 and 10^8 amp./cm.^{2} are by no means out of the question.

Fig. 2. As Fig. 1*b*. (× 700)

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Tensile Strength of Indium

This communication presents new approximate values of tensile strength and percentage elongation for indium.

Most tabulations[1,2] of properties list the following mechanical properties for indium containing 0·29 per cent impurities :

Tensile strength	7·99 tons/in.^{2} or 17,900 lb./in.^{2}
Percentage elongation in 3 in.	26·5 per cent

These data were taken from the work of W. Chandler Roberts-Austen[3] in which he studied the effect of adding small amounts of impurity metals on the tensile strength of gold. In his table of data[3] is listed the above-mentioned properties for an alloy of gold containing 0·29 per cent indium, which has since been misinterpreted as applying to indium with a 0·29 per cent impurity. Upon discovery of this error, we undertook an investigation of the true properties of indium.

We had obtained a limited amount of indium (99·97+ per cent pure) from the Indium Corporation of America in connexion with other studies. This was cast into three tensile bars using heated graphite moulds. The size and shape of the bar is not standard (see Fig. 1), but was assumed to be satisfactory for the test, since similar bars cast of lead produced results comparable to the accepted values for that metal.

Standard tensile test machines are unsuitable for testing material of such low strength. To overcome this difficulty, a method was devised consisting of gradually filling a bucket, suspended by the tensile bar, with lead shot. This method has two distinct advantages, namely, adaptability to low loads and control of loading rate. The latter is very important when one recalls that soft materials such as indium creep at room temperature.

The conditions and results of the tests were as follows :

Bar No.	Diameter (in.)	Gauge length (in.)	Area (in.^{2})	Load (lb.)	Elongation (in.)	Tensile strength (lb./sq.in.)	Percentage elongation
1	0·369	0·78	0·1070	42·25	1·32	395	69
2	0·371	0·78	0·1080	38·75	1·32	359	69
3	0·370	0·78	0·1075	44·13	1·34	410	72
					Averages	388	70

Fig. 2 shows the pulled bars. A loading rate of 8·6 lb./min. was used in all tests. The average tensile strength of indium is approximately 388 lb./in.^{2} and the average elongation is approximately 70 per cent. Fig. 3 shows the nature of the fracture in the three bars (they are numbered from left to right as in Figs. 1 and 2). Bar No. 3, which had the highest values of tensile strength and elongation also has the expected type of fracture, showing almost 100 per cent reduction in area. This tends to indicate that the averages of 388 lb./in.^{2} and 70 per cent are on the

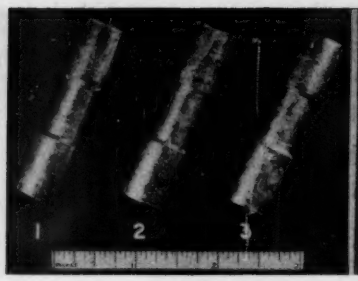

Fig. 1. Tensile bars as cast

Fig. 2. Tensile bars after fracture

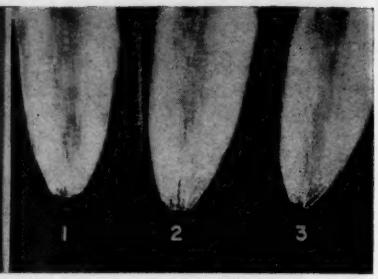

Fig. 3. Appearance of fractures

low side, probably due to imperfections in the cast bars.

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Mass Spectrometry of Substances of Low Volatility

A large range of substances which, because of their thermal instability or involatility, are unsuitable for admission in the gaseous state through a heated-inlet system into the ionization chamber of a mass spectrometer are usually studied by means of devices for volatilizing them very near the ionizing beam[1–6]. As a variant of the technique described by Bradt and Mohler[5], a Metropolitan-Vickers *M.S.*3 tube has been modified for the study of the effects of heat on coal and coal extracts in the temperature range 60–450° C.

The replacement of the original ion-source flange by one with additional electrical leads and an enlarged gas-inlet tube has made it possible to mount an electrically heated tubular furnace within 1 cm. of the entrance-port of the ionization chamber. The main differences from the apparatus of Bradt and Mohler are the following: (*a*) since the furnace has a heat capacity which is large compared with the sample holder, the thermocouple has been mounted in the furnace block; (*b*) the sample holder is mounted at the end of a glass rod extending up the gas-inlet tube in order that the whole unit may be moved in and out of the furnace magnetically by means of an iron bar sealed in the opposite end of the holder, thereby permitting out-gassing of the furnace, adjustments of temperature, and determinations of blanks; (*c*) the gas-inlet system remains connected to permit the introduction of mass-markers or to check the performance of the instrument under standard conditions.

The most satisfactory design of sample holder has been made from about 0·15 gm. of fine copper gauze rolled to form a cylinder which makes a good sliding fit inside the furnace tube. This is held on the probe by a small chuck, which also reduces the streaming of products back into the upper portion of the tube.

The normal procedure has been to study the growth and decay of the spectra at a succession of increasing temperatures. With the present vibrating reed electrometer and Sunvic *RSP*2 recorder (1 sec. full-scale deflexion) a scan of the mass region 53–215 can be made with reasonable accuracy in 6 min. This period is short compared with the life-time of the spectra produced by samples of 1–10 mgm. The amount of an individual substance released can be evaluated by time-integration of the height of a characteristic mass-peak because of the simple relation which exists between this integral and the sensitivity and leak-rate measured for the conventional inlet system.

Polystyrene was found to be a suitable material for testing the installation, and, as in the work of Bradt, Dibeler and Mohler[4], the monomer, dimer, trimer and tetramer were detected among the degradation products. For samples from different sources (for example, a commercial, catalyst-initiated polymer, a purified thermally initiated laboratory polymer, and an isotactic polymer) an interesting variation in behaviour has been observed with respect to the relatively small amount of decomposition which occurs in the temperature range 160–280° C. The details of a brief investigation of this phenomenon will be reported shortly.

A selection of coal vitrains is being studied by this technique. In addition to loosely bound aliphatic material with a wide range of molecular weight, a group of alkyl-substituted benzenes, naphthalenes and higher aromatics have been observed between 200° and 370° C. Above this temperature, where first traces of decomposition are signalled by the appearance of methane, corresponding series of substituted phenols and naphthols have been detected.

The instrument is also being used to characterize coal extracts and to estimate the distributions of molecular weights in various vacuum-distillation fractions.

Our thanks are due to the National Coal Board for the financial support of this investigation, further details of which will be published shortly.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

UNIVERSITY DEMONSTRATOR (with an honours degree in chemistry or agricultural chemistry, and preferably a special interest in the problems of soil fertility) IN SOIL SCIENCE, for duties which will involve demonstrating in the whole field of soil science—The Secretary, School of Agriculture, The University, Cambridge (August 6).

ASSISTANT IN ZOOLOGY—The Secretary of the University Court, The University, Glasgow (August 8).

LABORATORY STEWARD (over 21, previous experience in a biological, medical, biochemical or chemical laboratory, and preferably experience in the preparation of biological materials and photography) IN THE DEPARTMENT OF BOTANY—The Registrar, University College, Singleton Park, Swansea (August 8).

ASSISTANT LECTURER, Grade B, IN TELECOMMUNICATIONS AND ELECTRONICS—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (August 9).

ASSISTANT LECTURER IN INORGANIC AND STRUCTURAL CHEMISTRY, and an ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Registrar, The University, Leeds 2 (August 9).

LECTURER IN PHYSICS, and a LECTURER IN BACTERIOLOGY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 13).

SENIOR LECTURER or LECTURER (with a good honours degree and teaching experience) IN PHYSICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 15).

ASSISTANT LECTURER or LECTURER (preferably with some experience of structural analysis of organic and biomolecular compounds, and of the use of electronic digital machines) IN PHYSICS, with special reference to X-ray crystallography—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (August 23).

GUINNESS LECTURER IN BIOCHEMICAL ENGINEERING, to work in the Ramsay Memorial Laboratory of Chemical Engineering—The Secretary, University College, Gower Street, London, W.C.1 (September 1).

ASSISTANT LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Liverpool (September 6).

READER IN FLUID MECHANICS at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 11).

ASSOCIATE PROFESSOR (with postgraduate experience of veterinary anatomy) OF VETERINARY ANATOMY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 15).

READER, SENIOR FELLOW or FELLOW IN THE DEPARTMENT OF ASTRONOMY (Mount Stromlo Observatory), Research School of Physical Sciences, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 15).

SENIOR RESEARCH ASSOCIATE IN UPPER ATMOSPHERIC PHYSICS, to carry out experimental and observational research on the airglow and aurorae—Prof. D. R. Bates, F.R.S., Department of Applied Mathematics, The Queen's University, Belfast (September 20).

LECTURER IN PHYSIOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 22).

ASSISTANT LECTURER IN BOTANY—The Registrar, The University, Manchester (September 30).

LECTURER (with a degree in veterinary science or in science with honours in comparative anatomy) IN VETERINARY ANATOMY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

LECTURERS (2) (with an honours degree in civil engineering and preferably with research or teaching experience in either hydraulics or soil mechanics) IN CIVIL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

LECTURER or SENIOR LECTURER IN MATHEMATICS, and a LECTURER IN MATHEMATICS at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 13).

SENIOR RESEARCH OFFICER or RESEARCH OFFICER (male, qualified zoologist with experience of fisheries research) IN THE FISHERIES RESEARCH UNIT, Department of Zoology, University of Hong Kong, The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 30).

CHAIR OF ORGANIC CHEMISTRY in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

ASSISTANT LECTURER (with a degree or diploma in horticulture) IN HORTICULTURE—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

ASSISTANT TECHNICAL EDITOR (preferably between 20 and 30, with at least a pass degree in science, technology or arts) with the Ministry of Power in Sheffield, for work on reports and papers concerning safety in mines research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.266/8A.

BIOCHEMICAL TECHNICIAN IN THE PHYSIOLOGY DEPARTMENT of the Medical School, to take charge of the preparation of material for biochemical classes for medical, dental and science students, and to assist if required in research work of a biochemical nature—Prof. A. A. Harper, Department of Physiology, Medical School, King's College (University of Durham), Newcastle-upon-Tyne 1.

BIOCHEMIST, Senior Scientific Officer or Scientific Officer grade (with considerable experience in the field of protein chemistry and/or tissue metabolism) IN THE PHYSIOLOGY DEPARTMENT, to take part in a programme of research on the biosynthesis of protein in the mammary gland—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks quoting Ref. 58/14.

BIOCHEMIST (with a degree in biochemistry, and preferably a Ph.D.), for full-time research on biolcgical oxidation under Dr. V. Massey—The Secretary, Department of Biochemistry, The University, Sheffield 10.

BOTANIST (with a good honours degree and preferably some research experience, particularly in plant physiology), to join a small team engaged on studies of the constituents of natural rubber latex—The Director of Research, British Rubber Producers' Research Association, 48–56 Tewin Road, Welwyn Garden City, Herts.

FISH BIOLOGIST (with a good honours degree in natural science (zoology) and at least two years suitable postgraduate training or experience) at the Fish Culture Research Station, Malacca, Federation of Malaya, to study breeding, growth, feeding habits and life-history of fish of importance to fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/23/04.

INORGANIC or PHYSICAL CHEMISTS, Assistant Experimental Officer grade, at the Water Pollution Research Laboratory (D.S.I.R.), Stevenage, Herts, for work on physico-chemical problems in the study and prevention of pollution of rivers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.479/8A.

LABORATORY TECHNICIAN (preferably with chemistry or physics experience equivalent to G.C.E. "A" level), for specialized work—The Secretary, Wright-Fleming Institute, St. Mary's Hospital, Paddington, London, W.2.

LECTURER (with a suitable degree and industrial or research experience, and preferably an interest in one of the following items: applications of X-ray crystallography, isotopes, statistics or fatigue) IN THE DEPARTMENT OF INDUSTRIAL METALLURGY—The Deputy Registrar, The University, Birmingham 15.

POSTDOCTORAL FELLOW IN INORGANIC OR ORGANIC CHEMISTRY—The Chairman, Department of Chemistry, McGill University, Montreal, Canada.

PROFESSORS, ASSISTANT PROFESSORS and LECTURERS IN PHYSICS, MATHEMATICS, CHEMISTRY, BOTANY AND ZOOLOGY at the University of Baghdad, Iraq—The Cultural Attaché, Embassy of the Arab Union, 22 Queen's Gate, London, S.W.7, or direct to Secretary-General, University of Baghdad, Iraq.

RESEARCH SCHOLARS (with a first- or second-class honours degree, or the G.R.I.C.) IN CHEMISTRY, for work on the mechanisms of organic reactions and on organometallic compounds—The Registrar, The University, Leicester.

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with an honours degree and/or higher degree, and preferably a good knowledge of livestock and milk production), to develop current work on mastitis in relation to management—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/20.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent, several years experience in electronics or communications, and preferably also in airborne equipment design and pulse techniques), for duty at Orfordness, Suffolk, as a senior member of a team responsible for the design of air-borne telemetry equipment and associated ground stations, the organization and carrying out of flying trials on various types of weapons, and the analysis and evaluation of the results—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1845/34.

STUDENT TECHNICIANS IN THE DEPARTMENT OF BACTERIOLOGY AND PATHOLOGICAL MUSEUM—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

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